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TUBERCULOUS DISEASE
OF THE
BONES AND JOINTS

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I. TUBERCULOUS DISEASE OF THE BONES AND JOINTS IN GENERAL.

THE recognition of tuberculous disease in the bones and joints dates back to the early part of last century. In 1837 Nélaton wrote a work on "Tubercular Diseases of Bone," and contrasted the disease as it manifested itself in bone with tuberculosis affecting the lungs. Rokitansky, Virchow, and others among German pathologists referred to the frequency of tuberculosis in the bony system and in the joints. Friedlander, Koester, and other observers demonstrated the existence of histological tubercle in the diseased structures about such joints, and yet we find that less than thirty years ago the question as to the true nature of these bone and joint lesions was one of keen controversy. In 1877 Godlee described histological tubercle in "granulation tissue from white swelling of the knee" and looked upon it as a "very lowly organized form of inflammatory tissue" and not of the nature of true tubercle. Croft in 1881 presented several cases of joint tuberculosis before the Pathological Society of London, and his communication was accompanied by some excellent drawings by Greenfield of histological tubercle in both bone and synovial membrane. In his paper Croft gives an extended and interesting summary of the views held at that time by various observers, and indicated the uncertainty which prevailed among surgeons regarding the occurrence of tuberculous disease in joints and synovial membrane. All controversy was finally set at rest when Koch in 1882 discovered the bacillus of tuberculosis, and its presence was demonstrated in the diseased structures about a tuberculous joint.

Anatomical Considerations.—All parts of the skeleton present upon the outer surface a layer of compact bone which is very much denser in consistence

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than the cancellous osseous tissue which lies immediately subjacent. In the short bones the outer envelope of compact bone is of fairly uniform thickness, but in the long bones one finds great variation in this regard. The degree of greatest thickness is attained in the shaft of the long bones, but toward the articular extremity the cancellous tissue is covered by a very thin layer of compact bone. The layer of greater thickness in the shaft gradually fades away into the thin covering of the articular extremity. This fact is well shown in a frozen section through a joint such as, for example, a vertical section through the knee (Fig. 288). The trabeculae in cancellous tissue are arranged in a definite fashion so as to withstand the forces to which the individual bones may be subjected. An *x*-ray picture demonstrates the existence of this peculiar architecture in such bones as the os calcis or the astragalus (Plate XXVI, Fig. 2). Such bones reproduced by the *x*-ray and viewed stereoscopically show that the trabeculae are arranged in a double spiral—one system twisting from right to left and the other from left to right. The medullary cavity of a long bone, in which we find the soft marrow, is immediately surrounded by a thin layer composed of delicate trabeculae of osseous tissue, and this in turn merges gradually into the thick layer of compact tissue which composes the outer covering. The extremity of a bone as it enters into the formation of a joint, is covered by a layer of articular cartilage, which in the larger joints attains a thickness of about 2 mm. (Figs. 288 and 299). The various joints of the body are surrounded by a ligamentous envelope, the capsule, and this is thickened in various parts and supported by special ligaments which possess individual characteristics and functions in the various joints. The capsule is lined by synovial membrane which becomes attached to the bone at the margins of the articular cartilage. The synovial membrane, which is composed of connective tissue, presents upon its surface patches of cells that are irregularly branched and of an epithelioid appearance. The blood-vessels in and immediately beneath the synovial membrane are very numerous. Tendons or ligaments which pass through the articular cavities are also invested with synovial membrane, and the tendons of muscles acting upon a joint or upon a series of joints in succession are often invested with synovial sheaths, as at the wrist and ankle. In several of the joints folds of synovial membrane pass across the cavity as "synovial ligaments." Other folds of synovial membrane project into the joint cavity; these are very vascular, and usually cleft at their free border as "vascular fringes." Certain smaller non-vascular folds have been described as synovial villi; these occasionally contain cartilage cells and are sometimes made up wholly of fibro-cartilage. The cavity of the joint may be restricted in extent to that of the articular cartilage, or there may be, as in the knee most markedly (Fig. 288), diverticula or pouches lined by synovial membrane which extend beyond the limits of the articular surfaces. It is also well to recall the fact that there exist in many joints interarticular ligaments

which bind together non-articular areas of the intracapsular portions of the articulating bones, *e.g.*, the crucial ligaments of the knee-joint. The crucial ligaments are really portions of the posterior part of the capsular ligament which are isolated by the development of the condyles of the femur. So too the ligamentum teres of the hip-joint is isolated from the capsule by the development of the head of the femur, which expands as a wing on each side of the ligamentum teres, and by fusion of the wings isolates it from the capsule. One may note the existence of pads of fat in many localities between the synovial membrane and the structures which it covers. They fill up gaps and intervals in the joint cavity. Then, again, the existence of interarticular fibro-cartilages or menisci must be borne in mind as important elements in the structure of certain joints, and which must be reckoned with when we have to deal with disease in a joint possessing such structures.

It would appear that the articular surfaces are not in as close contact with one another as is generally believed to be the case. Koenig demonstrated the fact that in a joint like the hip these surfaces are not in contact in the dead subject; he showed that in frozen sections, where the positions of parts are unaltered, there is always found a layer of synovia between the articular surfaces. He endeavored to obtain apposition by firmly wiring the head of the femur to the acetabulum, but found that, even under such circumstances, contact was produced over but a small area of the articular surfaces. Braune and Fischer used screws to press the articular surfaces together and thus secured more extensive contact. It would seem, therefore, that extensive contact of articular surfaces is attained only when considerable pressure is applied, the effect of the pressure being to mould the elastic cartilaginous surfaces upon one another.

The anatomy of a joint in a growing child differs materially from that found in the adult. This fact is recognized in a most striking fashion if one studies the joints at different ages as they appear in frozen sections through the cadaver. Fig. 247 is a section through the body of a child one year old. At this early age the joints are in reality articulations between cartilages, and not between bones. This is well shown in the sections at the shoulder joint and at the elbow, whilst in the hip-joint a small islet of bone is seen to represent the centre of ossification for the head of the femur; again, the bottom of the acetabulum is largely cartilaginous. After the first year of life, however, the ossified epiphyses become more numerous in the skeleton and we then have to do with the epiphyseal disc of cartilage which persists for a variable period between the diaphysis and the epiphysis. These facts are shown very clearly if one compares a section through the foot and ankle of an adult with that through the foot and ankle of a child (compare Fig. 298 with Fig. 299); or sections through the knee-joint at these different ages (*vide* Fig. 287 and Fig. 288). We would therefore insist upon the importance of recognizing the anatomical dif-

ferences which exist in the joint structure of a child as compared with that of the adult—the cartilaginous extremity of a long bone in infancy, later the ossified epiphysis with the persistence of the epiphyseal disc, and finally the adult structure, where all trace of the epiphysis as an individual structure has dis-

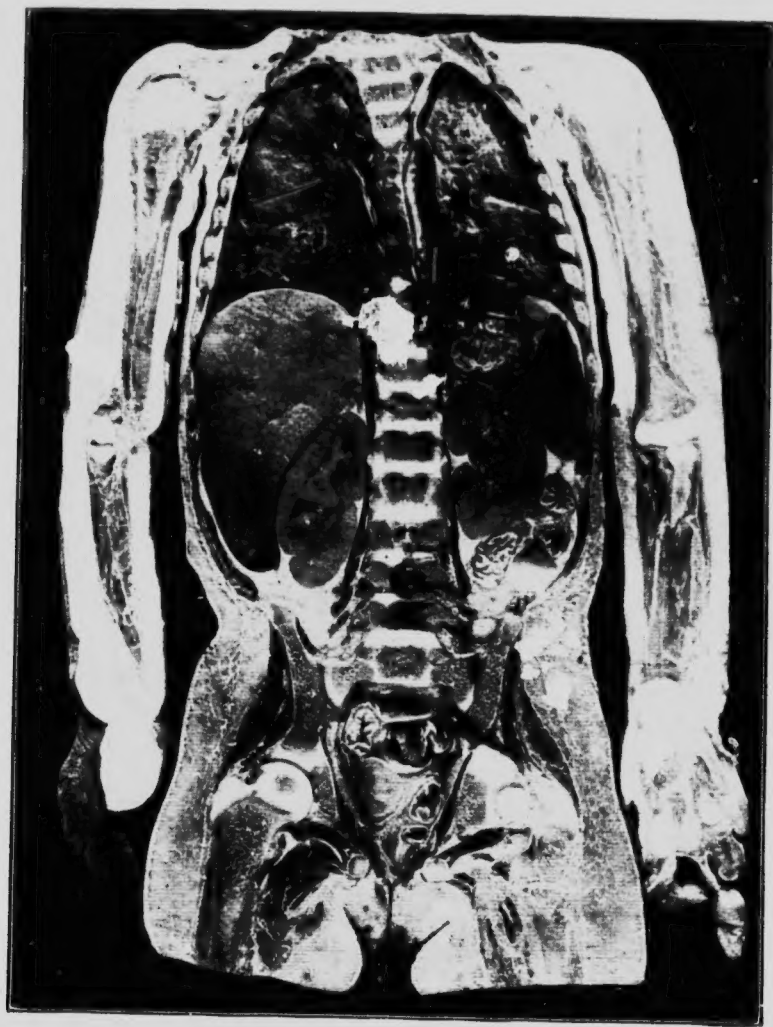


FIG. 247.—Frozen Section through the Body of a Child One Year Old. The hip, shoulder, elbow, and sacro-iliac joints are shown in the section. (Original.)

appeared as the result of its union with the diaphysis. The fact that the growth in length of a long bone is dependent upon the existence of the epiphyseal disc of cartilage was long ago demonstrated by John Hunter in the ingenious experiments which were carried on by him on the bones of growing animals. The truth of this fact is every day illustrated by experience; if the epiphyseal carti-

lage is destroyed, by injury, disease, or by operation upon a joint, then the bone ceases to grow in length at that point. It may be noted here that different kinds of epiphyses are recognized in the human skeleton. There are three varieties: First, those to which we have already alluded, separating the articular extremity of a bone from its shaft; these have been called "pressure epiphyses." Second, there are "traction epiphyses," which form processes for the attachment of muscles, *e.g.*, the great trochanter of the femur, which is separated for a time from the shaft of the bone by an epiphyseal disc, also the small trochanter for the psoas insertion. Third, the so-called "atavistic epiphyses," formed by the union of an element which formerly existed as a separate bone, *e.g.*, those of the ischium and pubis, the coracoid process, the epiphysis of the os calcis (*vide* Fig. 298), and the epiphysis of the olecranon (Fig. 253).

The blood vascular supply to a joint is free. The synovial membrane is the structure which is most freely supplied with blood-vessels. The articular cartilage in a healthy condition is devoid of blood-vessels and apparently depends, for whatever nutrient fluid it requires, on the vascular bone lying immediately subjacent to it, or upon the vascular supply to the synovial membrane which comes into immediate connection with it at its margins. There is, in fact, a narrow, vascular border immediately surrounding the cartilage at its circumference whose vessels are derived from the adjacent synovial membrane; these constitute the so-called *circulus articuli vasculosus*. When the articular cartilage becomes the seat of inflammation, then blood-vessels make their appearance in the cartilage. It is a fact worthy of note that the anastomosis of the main vessels of a limb occurs in the neighborhood of the articulations. For example, one may cite the anastomosis about the knee and ankle in the lower extremity, or about the shoulder and elbow in the upper extremity. In similar fashion the blood-vessels anastomose about the smaller joints.

The nerves are found to follow for the most part the course and distribution of the articular arteries. The articular cartilage in a physiological condition is devoid of nerves, and yet when it is the seat of inflammation it may become exceedingly sensitive. This characteristic development of sensitiveness in the articular cartilage when inflammation supervenes induces a series of clinical phenomena of importance from a diagnostic standpoint when the joint is diseased. Half a century ago Hilton published one of the most valuable observations that can be made for clinical purposes regarding the nerve supply to joints, and that was with respect to the association in nerve supply between the joint, the muscles moving the joint, and the sensory supply to the skin over the muscles. Take, for example, the circumflex nerve which in part supplies the shoulder joint; that nerve supplies the deltoid muscle, and it also supplies the skin over the deltoid. We see in arthritis affecting the shoulder how these various structures act in harmony. The effect of irritation of the nerve endings in the joint is to induce increased irritability of the muscle controlling

joint movement, and, in addition, to produce increased sensitiveness of the skin over the muscle. We therefore find in the case of an inflamed shoulder that the skin is sensitive to the touch and that any attempt to move the joint is guarded by muscular contraction. Lastly, regarding articular nerves, it must be remembered that there exists an association of nerve supply between the different joints of the same limb. The existence of this relationship sometimes results in certain subjective symptoms of disease which are most misleading unless correctly interpreted. For example, the associated nerve supply of the hip and knee may induce the subjective symptom of pain in the knee when the hip is the seat of disease. The anterior crural, the obturator, and the sciatic nerves are represented in both joints; this anatomical fact explains the misleading symptoms which may be, and frequently are, present in disease.

The strength of an articulation is dependent upon various factors. These may be summarized as: first, the conformation of the articular extremities of the bones; second, the development and strength of the ligaments of the joints; and, third, the support of the muscles which immediately surround the joint and control its movements. These three factors may contribute to an equal degree in the strength of an individual joint, but we frequently find things otherwise, and there are examples of joints which are notably osseously strong, others which are ligamentously strong, and yet again others which are muscularly strong. For example, the shoulder joint is muscularly strong, the osseous conformation of the articular extremities of the bones adds little to the strength of the articulation, and the same might be said of the ligaments; on the other hand, the muscles about the joint are peculiarly effective in strengthening the articulation. The fact is frequently demonstrated by the ease with which dislocation is produced when these muscles are taken at a disadvantage, as in alcoholic narcosis. The acromio-clavicular joint is ligamentously strong and osseously weak; the peculiarity of the muscular attachments here also adds strength to the articulation; thus the deltoid and the trapezius are each attached to both clavicle and acromion, and each would have the effect of maintaining the bones in apposition when in active contraction. Lastly, the hip joint is obviously dependent for its strength largely upon the osseous conformation of the acetabulum which receives the head of the femur; the grip of the head of the bone is also increased by the cotyloid ligament which deepens the socket for its reception. In dealing with the various articulations, therefore, it is well to have in view the peculiar factors which contribute to the strength of the individual joints, and these factors should be conserved as far as possible in our surgical treatment.

It has been assumed that atmospheric pressure is a factor in keeping the joint surfaces in contact. Weber divided all the muscles about a hip joint in a cadaver and then found that the weight of the limb was not sufficient to

draw the joint surfaces apart, but on boring a hole through the bottom of the acetabulum the head at once fell downward. He found, moreover, that a weight of twenty kilos was necessary to overcome the effect of atmospheric pressure sufficiently to pull the joint surfaces apart. It is doubtful if the results of such an experiment could be applied to any other joint. In most joints comparatively small traction force will separate the joint surfaces, the space resulting being filled in by the surrounding tissues or by synovia.

Etiology.—The essential cause of tuberculous disease in the tissues of the body is the bacillus of tubercle; if this bacillus does not enter the body, then tuberculous disease cannot occur. It is both interesting and instructive to study the gradual development of our knowledge regarding the etiology of tuberculosis affecting bones and joints. All caseous deposits occurring in the tissues were called "tubercles" by Laënnec when he wrote on diseases of the chest in 1834. These tubercles of Laënnec were shown by Virchow a few years later to present considerable variation in their origin, and it was not until Cohnheim in 1880 placed definite restrictions on the word "tubercular" that we arrived at limitations which more or less accurately define the field of tuberculous disease as we view it to-day. Cohnheim's definition was: "All is tubercular which, by transference to properly constituted animals, is capable of inducing tuberculosis, and nothing is tubercular unless it has this capability." It was not, however, until 1882, when Koch first published his discovery, that the cause of tubercle was shown to be a specific bacillus. Koch defined tubercle as "any growth of newly formed tissue which contains the tubercle bacillus, quite irrespective of situation, histological structure, or distribution." After the discovery of Koch, the development of tuberculous disease in the tissues of the body was more thoroughly understood, and, among other manifestations of tuberculosis, joint and bone disease was more closely investigated. Koch in his original investigations, among other tissues examined, found bacilli present in thirteen cases of tuberculosis of the joints and ten cases of tuberculous affections of the bones. Long before the time of Koch it had been contended that certain manifestations of disease in bone were of an origin similar to that of pulmonary tuberculosis. Thus Delpech in 1816 believed that Pott's disease of the spine was of an origin similar to that of phthisis pulmonalis, and he called the disease "tubercular disease of the vertebrae." Nichet described the tuberculous nature of Pott's disease of the spine in 1835, and Nélaton wrote on "Tubercular Diseases of Bone" in 1837. Later, Virchow, Rokitsansky, and others adopted the same view. Investigation of the histological structure of tuberculous tissue demonstrated the almost constant presence of certain characteristic elements, as, for example, the presence in miliary tubercle of giant cells, of epithelioid cells, and of a fine reticulum, each and all of which were described as essential features of the disease. Koester in 1869 was, however, the first to study thoroughly these diseases of the joints histologically.

and to recognize fully their tuberculous nature. He examined the synovial membrane in several cases of white swelling of joints, and found in all of them nodules of the size and character of miliary tubercles, having one or more giant cells in their centre, lymphoid elements in their periphery, and a greater or less tendency to fatty degeneration, and he pointed out that so long as the conception of the term "miliary tubercle" was a histological one, so long must these histological tubercles in the swollen synovial membrane be looked upon as true tubercles (Cheyne). Koenig and Volkmann in 1871 made similar deductions from their findings in the histology of the affected tissues about a joint. Koenig ascribed the origin of certain cases of cheesy suppuration in joints to the presence of tuberculous deposits in the synovial membrane, and demonstrated further the presence of histological tubercle in the granulations lining the sinuses about a diseased joint. Observations of this kind paved the way for the recognition of the true nature and etiology of tuberculous disease as it is manifested in joints and in bone. Koch's discovery placed the theory of the origin of these diseases on a firm basis. The bacillus was found in the synovial membrane and in the bones at the seat of disease, and this was proven to be the etiological factor at work. It was found that injection of a pure culture of the tubercle bacilli into a joint directly, or into a nutrient artery of a bone, excites in the bone and joint a fungating disease analogous to that which is now known to be indicative of tuberculosis. It was formerly thought that it was impossible to have an isolated tuberculous joint affection without the individual suffering from general tuberculosis, but it soon became evident that localized joint affection of a tuberculous character was exceedingly common, and the victim of tuberculous joint disease was not necessarily the victim of general infection. Further, it was shown that joint lesions previously called "strumous" or "serofulous" were all tuberculous in origin and were due to the activities of the tubercle bacillus. It is therefore an accepted scientific fact that the essential etiological factor in the production of tuberculous joint disease is the *Bacillus tuberculosis* of Koch.

There are certain predisposing causes in the production of tuberculous arthritis, and among these we may first consider *trauma*. Of three hundred and fifteen cases of tuberculous diseases of the bones and joints admitted into the Hospital for Sick Children, Toronto, one hundred and thirteen (*i.e.*, 35.8 per cent) gave a definite history of injury occurring a month or six weeks before the onset of symptoms. It is often possible to elicit a history of injury when one inquires into the cause of a tuberculous joint lesion. This history must not be taken too seriously, however, as the cases which we are considering occur chiefly in children who frequently injure a joint in play without any ill effects. We cannot, therefore, directly connect the onset of tuberculous disease with injury in all cases with certainty, but frequently the sequence of events is so obvious that we must look upon injury as a predisposing cause.

For example, there was admitted to the Toronto General Hospital a lad of seventeen who had tuberculous disease of the ankle, and who gave the following history: Fifteen months previously he had been thrown from his horse and sprained his ankle. He remained in bed for three weeks and then, in spite of continued pain, began to go about; the ankle became swollen and the pain increased. He would rest and resume walking intermittently without permitting complete recovery at any time; finally, twelve months after the accident, he had a plaster cast applied and the foot kept at rest. Three months subsequently, when he came under the care of the writer, he had a typical condition of tuberculous joint disease, with a carious cavity in the astragalus as large as a walnut. In this case the trouble was no doubt initiated by the injury to the ankle joint received by the fall from his horse.

Attention has frequently been called to the fact that slight injury is more likely to cause tuberculous arthritis than more severe injury. Cheyne would have us believe that the explanation lies in the fact that more reparative material is thrown out in the more severe injury; the tissues react to the greater damage more energetically; and he claims that on this account the resistance established to the inroads of the bacillus is greater after a fracture than after a sprain. The writer believes, however, that the explanation is rather to be found in the fact that after a severe injury the part is necessarily kept at rest until repair has taken place, while, on the other hand, in less severe injury, the individual continues to use the injured limb, and a chronic inflammatory condition results which predisposes the injured joint to the inroads of tubercle and maintains conditions favorable for its development.

The relationship of injury to tuberculous arthritis has been demonstrated experimentally. Krause inoculated animals with tubercle bacilli and then injured the joints, succeeding in this way in producing localized lesions in the injured joints; he showed that slight injuries were more likely to induce tuberculous deposit than more severe ones. Krause also found that in a tuberculous animal a fractured bone unites readily without the production of local disease. Similarly, one finds in practice that the victim of tuberculous arthritis who sustains a fracture may have perfect union without the development of tubercle at the seat of injury. Thus one may instance the case of a boy of eight years of age with advanced tuberculous disease of the left knee joint; he fell off a rocking-horse and fractured the left thigh bone about its centre; the fracture was examined under chloroform and carefully adjusted and splinted; union occurred in quite normal fashion without the production of local tuberculous disease.

The existence of tuberculous disease elsewhere in the body predisposes to the production of tuberculous arthritis. So it is we find patients the victims of pulmonary tuberculosis who are not infrequently attacked by tuberculous joint disease. A curious circumstance, too, is illustrated in the sequence of events

sometimes observed in an individual who has long since recovered from a tuberculous joint affection, but who contracts pulmonary tuberculosis, shortly after which the old joint affection reasserts itself. Thus a patient had hip-joint disease with abscess at six years of age, from which he recovered with some deformity and disability of the limb; at twenty-four years of age he contracted pulmonary tuberculosis; the lung affection seemed to clear up for a time while he resided in a sanitarium, but during that time the old hip trouble lightened up afresh, an abscess formed, and a focus of carious bone was found in the femoral neck. The hip trouble had in this case remained quiescent for seventeen or eighteen years, and then reasserted itself when the patient contracted pulmonary tuberculosis; the chest trouble now made rapid progress and soon proved fatal.

The Side of the Body Affected.—Out of 205 cases of patients over five years of age suffering from hip-joint disease and knee-joint disease admitted into the Hospital for Sick Children, Toronto, there were 120 in which the disease was on the right side and 78 in which it was on the left; that is to say, three-fifths had the disease on the right side and two-fifths on the left, or, in other words, there were half as many more affected on the right side than there were affected on the left side. In patients under five years of age the cases were equally divided between right and left. The conclusion from these figures is that after the child begins to run about freely the right limb is more likely to be affected than the left.

The age of the individual as a predisposing factor may now be considered. Tuberculous arthritis is much more commonly met with in the child than in the adult. Statistics proving this fact have been compiled from time to time, and of these one may quote those of Cheyne. The following table shows the percentage proportion of cases of bone and joint disease:

Age.	Total.	Males.	Females.
1-5	23.2	14.3	8.8
6-10	16.	9.5	6.5
11-15	14.6	9.5	5.
16-20	15.	9.5	5.8
21-25	8.5	6.3	2.
26-30	8.8	5.3	3.3
31-35	4.	4.	..
36-40	3.	2.4	0.8
41-45	2.	2.	..
46-50	2.	1.8	0.4
Above 50	2.	1.	1.

As Cheyne points out, however, this table does not represent the actual risk to life at the different ages indicated. For example, the fact that the largest number of cases presenting themselves for treatment were persons under five years of age may possibly be accounted for by assuming that a larger number of individuals are alive at that age. Cheyne has corrected the

above table after the manner suggested by Fassbender, who calculated the number of persons alive at the different ages, and then indicated the ratio per thousand of the occurrence of such diseases. The following table shows the results, both of Cheyne and of Fassbender, stated in percentages:

TABLE SHOWING THE RATIO PER THOUSAND (EXPRESSED AS A PERCENTAGE) OF CASES OF DISEASE OF THE SEVEN LARGER JOINTS TO THE PERSONS ALIVE AT THE DIFFERENT AGES INDICATED (CHEYNE).

Age	Apparent Frequency.	Real Frequency. (Cheyne.)	Real Frequency. (Fassbender.)
1-5	232	167	108
6-10	153	134	145
11-15	150	145	113
16-20	153	164	157
21-25	85	98	77
26-30	88	120	109
31-35	41	60	76
36-40	30	48	106
41-45	20	36	66
46-50	20	42	85
50-60	14	17	About 60
60-70	0	0	About 42
70-80	7	33	About 21

It would appear, therefore, from the foregoing table that there is not as great immunity from tuberculous joint disease in old people as might be supposed if one were to study only a table of statistics which has not been corrected as above. The fact remains, however, that we are called upon to treat a larger number of cases in young children than in individuals of any other age. In the Hospital for Sick Children, Toronto, patients are admitted at fourteen years of age and under, and the following statistics have been compiled in such a manner as to show the ages of 310 individuals who had been admitted to the wards as patients suffering from tuberculous joint disease:

Age.	Number.	Percentage Number.
1	2	0.645
2	10	3.2
3	24	8.
4	28	9.
5	39	12.6
6	41	13.2
7	29	9.3
8	22	7.1
9	26	8.4
10	18	6.
11	20	6.4
12	22	7.1
13	15	5.
14	14	4.6

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The above table shows a gradual increase in frequency up to six years of age, when the maximum is reached. These figures may be grouped into definite periods as follows:

Age.	Number.	Percentage Number.
1-5	103	33
6-10	136	44
11-14	71	23

If these figures be taken along with those of Cheyne and Fassbender it becomes obvious that the disease is much more frequent in the first decade of life than at any other period. The statistics of the Toronto hospital would indicate that in children the disease is most common about the fifth and sixth years.

There is also apparently a distinct relationship between the age and the particular joint affected. During the first decade of life, for example, the hip and knee are more likely to be affected. The following table from Cheyne shows the relationship in question:

	First Decade.	Second Decade.	Third Decade.	Fourth Decade.	Fifth Decade.
Hip	30.2	20.3	4.8	..	12.5
Knee	29.5	22.8	18.2	36.6	6.2
Ankle	5.4	5.9	3.6	3.3	12.5
Tarsus	4.6	5.9	8.4	3.3	18.7
Shoulder	..	1.6	4.8	..	..
Elbow	6.7	9.2	6.	13.3	18.7
Wrist	.6	8.4	15.8	13.3	6.2
Fingers	1.5	4.2	2.4	..	..
Ribs	..	..	1.2	10.	12.5
Os calcis	2.6	2.4	2.4	3.3	..
Odd bones	6.7	3.2	3.6	..	..
Spine	12.	15.2	28.	20.	12.5

Clinical experience leads to the conclusion that the age of the patient has a marked effect on the severity of the disease. This is noticed in the occurrence of suppuration. Thus Cheyne's statistics show that during the first decade 66 per cent, during the second decade 74.5 per cent, and during the third decade 86.2 per cent, suppurated. Cheyne points out, however, that the percentage statement is too high for all cases, as the statistics were compiled from the indoor patients and did not include outdoor cases, most of which were non-suppurative. Nevertheless, it illustrates the fact that suppuration is more likely to occur as age advances.

In considering predisposition we must include *sex* as a factor. It would appear that males are more liable to tuberculous arthritis than females. Cheyne's statistics show that in 386 patients under treatment in hospital, 251, or 65 per cent, were males, and 135, or 35 per cent, were females. There is some varia-

tion in the joint affected in relation to sex as shown from the following table from Cheyne:

	Hip.	Knee.	Ankle.	Tarsus.	Shoulder.	Elbow.	Wrist.
Males	59.7	57.6	81.9	85.8	50	74.3	75.9
Females	40.3	42.4	18.1	14.2	50	25.7	24.1

The disease is more severe in males than in females. This is the case whether we test the matter by the severity of the measures required for cure, by the results of treatment, or by the frequency of suppuration (Cheyne).

The Influence of Heredity.—There can be no doubt of the facts that tuberculosis frequently attacks different members of the same family, and that other families are peculiarly free from it. The explanation of this circumstance is not by any means established by saying that the disease is inherited. In fact, we may assert that the disease itself is never inherited. On the other hand, the predisposition to the disease may be handed down from parent to offspring. Some individuals seem to have a more diminished power of resistance against tuberculosis than others, and the constitutional conditions which characterize that diminished power of resistance would appear to be inherited.

Out of 315 cases of tuberculous disease in bones and joints admitted to the Hospital for Sick Children, Toronto, 131 (*i.e.*, 41.5 per cent) gave a history of tuberculosis somewhere in the family tree. Then again, 73 of these cases (*i.e.*, 23 per cent) had tuberculous parents. It may be further mentioned regarding these 315 cases that 156 (about 50 per cent) had been delicate from birth. The remainder were fairly strong, or else the history had omitted to mention anything about the previous health.

The habit of life of the individual may be a predisposing cause. Bad hygienic surroundings render the individual more liable to the disease. These may consist of dark, damp, and badly ventilated quarters and insufficient and unsuitable food. In speaking of the quality of the food, the following interesting and suggestive account of Bidder's views is given by Cheyne: "Bidder, in speaking of the treatment of these diseases, lays great stress on the avoidance of substances rich in potash, and also of starchy materials, and strongly advises the employment of albuminous foods rich in soda and fat. A probable confirmation of this view is the noteworthy fact that tuberculosis is, as a rule, very common in herbivorous animals, and can usually be very readily induced in them, while, on the other hand, it seldom occurs in the carnivora"; *e.g.*, rabbits and guinea-pigs are easily inoculated with tubercle, but dogs and cats are comparatively insusceptible to the contagion. Villenin first demonstrated this fact in 1866. Man, who employs a mixed diet, stands midway between these two groups in his susceptibility to this disease, tuber-

culosis being more often local and less virulent than in the herbivora, while it is much more frequent and destructive than in the carnivora. In this way also Bidder explains the much greater frequency of tuberculous disease in the western part of Germany than in the eastern, although the density of the population is greater in the latter; it appears that the inhabitants of Eastern Germany employ less vegetable diet than do those of the west, and eat large quantities of salt meat.

Pathology.—The term "tubercle," meaning a nodule, or little node, was originally applied by Laënnec to the gross appearances presented in tissue the seat of a tuberculous lesion. Two varieties were recognized: the "gray or mililiary tubercle," approximating a millet seed (*milium*) in size; when caseation occurred in these they changed in color and were then called "yellow tubercles." At a later period, when the microscope revealed the fact that these gray and yellow tubercles were composed of aggregations of minute, invisible, translucent masses, each composed of cells grouped in a characteristic fashion, a third variety was described for which the name "histological tubercle" or "submiliary tubercle" was provided. It must be clearly understood that all these terms are applied to different manifestations of the same process due always to the same etiological factor, namely, the bacillus of tuberculosis which produces, when introduced into the body, an inflammatory neoplasm in the tissues.

The histological features characteristic of tubercle consist of a special grouping of cellular elements. There is a giant cell, situated usually in the centre of the tubercle, containing many nuclei. These nuclei are usually grouped in the form of a horseshoe within the cell; they may be collected at one end of the cell, or occasionally they are found scattered irregularly through the cell. The cell possesses at its periphery many fine processes which pass out among the other cellular elements and are lost in a fine reticulum which pervades the whole tubercle. Surrounding the central giant cell are a series of cells which, because of their appearance, have been called "epithelioid cells." A peripheral zone of cells surrounding the epithelioid cells consists of leucocytes and these constitute the "small round cells" of the tubercle. The "reticulum" of tubercle has been described by some observers as simply pre-existing connective tissue invaded and pushed aside by the new cells; by others it is described as composed of processes of the epithelioid cells. A thickening of the reticulum at the periphery may constitute a more or less defined capsule for the tubercle. In the meshes of the reticulum are found the cellular parts of the tubercle. We may therefore speak of four elements in the tubercle—the giant cell, the epithelioid cell, the leucocyte, and the reticulum.

The type of cell arrangement which we have described for tubercle may be departed from in certain cases, and the tuberculous tissues may exhibit a different histological arrangement from that described. For example, the giant

cell may be absent, or, again, changes may have supervened to produce a fibrosis of the tubercle, and then a fibrous nodule exists as the manifestation of the activities of the tuberculous virus in the tissues.

Again, it may be noted that a condition of more or less infiltration of the tissues by the tuberculous process, without the manifestation of discrete tubercles, has been observed. In these cases there is a massing of the epithelioid cells in more or less columnar-shaped groups, in which bacilli are often found in large numbers. The term "tuberculous infiltration" has been applied to this condition, and from a study of its histological characters Cheyne was inclined to look upon the epithelioid cell as the essential histological element of tubercle.

Different views are held as to the origin and the significance of the giant cells. It is held that they represent lymph spaces in which a coagulum has formed, the nuclei being derived from the epithelium of the wall of the space. Baumgarten believes that the giant cell represents an overgrown cell in which active division of the nucleus has occurred without corresponding division of the protoplasm of the cell, and that this peculiar effect is produced by the irritation of the bacillus in its interior. It must be remembered that giant cells are not peculiar to tubercle; thus they are found in bone marrow, in granulation tissue, in gummata, sarcomata, actinomycosis, in inflamed serous membranes, and in the placenta. The epithelioid cells are two or three times the size of the white blood cells, they often become caseous, but in the process of healing they appear to atrophy and become converted into fibrous tissue. As a fact, the epithelioid cells are fibroblasts, and as such they tend to form fibrous tissue unless they are overtaken by the process of caseation. The leucocytes are present as a barrier zone around the central aggregation of epithelioid cells. The presence of the leucocytes here is simply a manifestation of the reaction of the tissues to the presence of an irritant, producing this characteristic feature of an inflammatory process.

In consequence of the fact that a tubercle is non-vascular it sooner or later undergoes retrogressive changes and becomes fatty, necrotic, and caseous. While these changes may be readily observed in tubercle under the microscope, we have frequent manifestations of this necrotic tendency in the gross anatomy of tuberculous tissues. Where a number of tubercles have grouped themselves together it is obviously the central portion of the mass which is most likely to suffer from lack of nutrition, and there we find retrogressive changes going on, with the production of a necrotic centre in the tuberculous tissue; lime salts may be deposited in this, producing some degree of calcification. The central necrotic mass may liquefy and form what is known as a tuberculous or "cold" abscess.

The presence of the specific virus of tubercle may be demonstrated in the affected tissues. It is not always easy or possible to find the bacillus, but

with appropriate methods of staining, and after careful search, they can usually be found. Cheyne accounts for the fact that the bacilli can be demonstrated only in small numbers, and sometimes not at all, by suggesting that they are growing slowly and with difficulty, and that their staining reactions differ at different periods of their existence. It would appear that our present methods of staining do not justify us in drawing conclusions as to the number present. Bacilli are found in the giant cell and in and among the epithelioid cells, but they are not at all found in the inflammatory cells, *i.e.*, the leucocytes. The bacilli are found in largest numbers in the giant cell, and where they are few in number they are usually restricted to the giant cell.

The gross appearance of the lesions which are present in tuberculous arthritis is sufficiently characteristic. In many cases the synovial membrane becomes uniformly thickened and possesses a pulpy, gelatinous consistence; if incised, the surface of the section is usually of a gray clay color. The inner surface becomes covered with a thick layer of jelly-like fungiform granulations, or bunches of these hang from the vascular fringes. Occasionally these appear as a great mass of synovial villi of jelly-like consistence hanging free in the joint cavity, and, in the knee, for example, forming a very considerable amount of the thickening which is so observable on examination of the affected joint. While the usual form in which we find the disease manifested in synovial membrane is in this diffuse, pulpy thickening of that structure, occasionally the disease may be more limited and may present itself as one or more isolated nodules. Then, again, there is the acute miliary manifestation of tubercle. Koenig describes miliary tubercles in synovial membrane in cases of acute general tuberculosis. Lastly, there is a tuberculous involvement of the synovial membrane described by Koenig and Volkmann, in which the joint contains fluid, but there is no marked thickening of the synovial membrane to start with, although the disease is primarily synovial; subsequently swelling of the synovial membrane comes on, and then, quite likely for the first time, the true nature of the condition is recognized. Koenig has examined these cases at an early stage and states that there is a formation of a thin layer of tubercles on the surface of the synovial membrane, along with a slight amount of chronic inflammation. In the condition known as "empyema tuberculosum" a very similar condition is present, but caseous pus is found in the joint cavity, while the synovial membrane is not thickened; these cases are more commonly met with in old people. A very similar condition is found in some cases after a caseous deposit has opened into a joint (Cheyne.)

In the diffuse thickening of the synovial membrane, which is by far the most usual form observed when these patients are first seen, or when we open a joint for tuberculous disease, there are certain characteristic appearances with which we become familiar and which we have described, but the area of actively growing tubercles may be uniformly distributed over the

inner surface of the membrane, giving us the gross appearance of fungiform, jelly-like granulations projecting into the joint cavity; this is supported externally by tissue, the seat of a non-infective chronic or subacute inflammation, and presenting a very considerable degree of thickening, in which tubercles are absent. This outer layer of thickening is of firm consistence, in marked contrast to the inner lining of soft tuberculous material. It is an example of a chronic progressive fibrosis surrounding the area of tuberculous activity. If the disease continues to progress, the outer area of inflammatory thickening may be invaded until a considerable mass of soft and often caseous material is found replacing the normal synovial membrane. Cheyne considers that these cases of invasion of the synovial membrane from within are in reality secondary lesions and are produced as the result of a primary deposit in the bone reaching the joint cavity freely and rapidly, causing infection over the entire surface of the synovial membrane. It would appear, however, that those cases which present the greatest degree of synovial thickening are primary synovial lesions, and in these the deposit of tubercles may appear in any part of the substance of the membrane, or even in the sub-synovial tissue. From this starting point there is soon an invasion of the entire membrane by the tuberculous growth, preceded by inflammatory swelling and infiltration of the tissue.

The condition of limited tuberculous involvement of the synovial membrane is comparatively rare. Koenig, Riedel, Cheyne, and others have described nodular, often polypoid, growths occurring generally in the knee. One or more firm nodules may project from some part of the capsule, generally in the pouch above the patella; the condition is not infrequently accompanied by hydrarthrosis. The entire synovial membrane becomes reddened and often thickened, and the fluid within the joint frequently contains rice-like bodies. Histologically the nodules are found to contain tubercles closely packed together.

The pathological changes which occur in the bone in tuberculous disease may now be described. The bone is first affected in the cancellous tissue, so that we find the earliest manifestations of the disease in the cancellous ends of the long bones. The tuberculous deposit may be found in the epiphysis or in the diaphysis, *i.e.*, on either side of the epiphyseal cartilage in the growing child. Not infrequently the disease spreads from the cancellous bone to the epiphyseal cartilage, and thus the cartilage becomes secondarily involved and destroyed, or, on the other hand, the disease may first separate and then lead to the destruction of the articular cartilage. At certain stages of the disease it is common to find the cartilage completely separated, as it overlies the tuberculous deposit in the bone. At later stages the articular cartilage is honey-combed, becoming absorbed and perforated at various points. Finally, the cartilage may almost completely disappear. We shall consider the changes

which lead to the destruction of the cartilage later, but in the mean time let us consider the histological changes which may be studied in the bone.

The manifestation of histological tubercle is similar to that described earlier in this article, modified only by the peculiarities of the osseous tissue in which it now develops. The effect upon the bone, however, leads to certain characteristic changes. In the earliest phases we have the tubercles occurring in isolated portions of the cancellous tissue, and, as giant-celled systems make their appearance, the trabeculae of bone forming the network of the spongy texture becomes greatly atrophied; an inflammatory process surrounding each focus leads eventually to the formation of granulation tissue; in places the osseous trabeculae are destroyed, neighboring foci of tubercle merge together, the centre of the tubercles thus grouped becomes necrosed and fatty, while the bony trabeculae in this area entirely disappear, and thus an area of the cancellous tissue, varying in extent in different cases, becomes greatly altered and is replaced by masses of tissue in which one can distinguish caseation in the midst of a tuberculous focus; around about the central caseous area one can distinguish actively growing tubercles, and beyond that, again, forming an encircling zone, we find inflamed bone where the absorption of bony trabeculae is going on and where that tissue is being replaced by granulation tissue. The bone is thus softened and loses its firmness to a large extent; a probe introduced into it readily penetrates the cancellous tissue and thus we have the picture of what we are familiar with as "caries" or "ulceration of bone." The term caries has long been applied to this broken-down and disintegrated condition of the bone in which the osseous trabeculae are softened and rarefied, while the interstices are filled with half-purulent material containing much granular and oily debris. The atrophy which occurs in these cases is often very extensive in amount and extreme in degree, so that if a specimen of such diseased bone were dried the osseous trabeculae would be found to be represented by a most delicate tracery or network of fine bony spicules and the medullary spaces unduly enlarged. This constitutes the condition of "rarefying osteitis." In the immediate vicinity of the tuberculous focus the bony trabeculae may be thicker than normal, thus presenting the condition of sclerosis, and in this position, too, the chronic inflammatory process may lead to the formation of fibrous tissue. If the disease progresses, then the tuberculous process invades the area of inflamed bone which surrounds the primary focus, and this in turn undergoes changes similar to those described, until eventually the disease reaches the surface of the bone. It may thus gain the articular surface, and may there invade the articular cartilage; eventually this is perforated and the joint becomes involved. This becomes manifest by the presence of fluid in the joint, which is at first merely an inflammatory exudate, but soon appears as caseous pus, which collects to a variable amount in the joint cavity. When the tuberculous process spreads toward the epiphyseal

cartilage, the irritation at that point not infrequently leads to increased activity in the changes which are going on there in the growing bone, and this results in the manifestation clinically of increased length of the affected bone. (This occurs particularly at the knee joint.) Finally, the epiphyseal cartilage may be destroyed in the process. Then again, the disease may reach the surface of the bone immediately under the reflection of the synovial membrane over the bone. In such cases the synovial membrane becomes invaded. At first it is the seat of chronic inflammation, and this in turn becomes invaded by the tuberculous process. Thickening and destruction of the synovial membrane occur, as has been described. In turn the ligaments about the joint become the seat of disease; these become softened and may be completely destroyed where they are invaded. An abscess may form and come to the surface or open into the joint. By this means, in a case which advances to extensive destruction of tissue, there may be complete disintegration of the joint structure. The disease may, however, reach the surface of the bone quite beyond the attachment of synovial membrane or ligament, and under such circumstances the soft tissues may become invaded next to the surface of the bone and outside the joint, and may there lead to the formation of an extra-articular tuberculous abscess.

The chronic inflammatory process which surrounds the tuberculous focus may lead to a thickening of the osseous trabeculae to such an extent as to constitute a sclerosis of the bone. This may continue while the tuberculous focus has become quiescent; the tubercles may disappear and their place may become occupied by granulation tissue, which in turn is transformed into fibrous tissue. Thus it is that cases of tubercle in bone which have undergone spontaneous cure have the infected area replaced eventually by sclerosed bone and fibrous tissue.

Another condition of affairs sometimes develops, viz., one in which the vitality of the bone at the seat of disease is destroyed and a mass of cancellous bone perishes and is separated as a sequestrum. An example of this is well shown in Fig. 248, where in a frozen section a sequestrum is apparent, situated in the head of the astragalus. The section was made through a tuberculous ankle. In the condition of necrosis in tuberculous disease it would appear that sclerosis precedes the death of the portion of affected bone, and as the sequestrum is being separated one finds in the soft tissue surrounding the sequestrum numerous actively-growing tubercles. These may caseate and form pus as the process still further extends, and so we have the sequestrum lying in a pus cavity, the walls of which are represented by cancellous tissue, which is the seat of tuberculous deposit, or which very often becomes sclerosed as the result of condensing osteitis, as in the case figured; surrounding this is an area of rarefying osteitis. The sequestra are of various shapes and sizes.

A rare manifestation of tubercle in bone is that of acute diffuse miliary

tuberculosis. This is said to occur quite apart from any large deposit. It is of unusual occurrence except in cases of acute general tuberculosis.

Having now discussed the changes in synovial membrane and in bone, we may proceed to describe the changes which occur in cartilage.

Here again the changes are those which result from a chronic inflammatory process. It would appear that, as the tuberculous disease progresses in the cancellous bone and approaches the articular cartilage, the latter soon shows indications of inflammation. The congestion of the cartilage is evident at an early stage, and is the more marked because of the fact that cartilage in its normal condition possesses few blood-vessels, and instead of the usual



FIG. 248.—Tuberculous Deposit in the Astragalus. There is a small sequestrum lying in a cavity, the walls of which are formed by dense sclerosed bone. The patient had had the ankle joint excised for tuberculous disease eleven years previously. (Original.)

bluish-white appearance it now becomes pink in color and is obviously invaded by the development of new blood-vessels in its substance. The cartilage cells undergo a change: they proliferate, the cartilage matrix becomes absorbed, and the normal structure becomes replaced by granulation tissue. The cartilage thus becomes perforated in spots, giving us the characteristic worm-eaten appearance which is familiar to those who have had the opportunity of seeing the interior of a tuberculous joint at this stage of its existence. In this granulation tissue tubercles are found, and eventually, in patches, the whole thickness of the cartilage disappears from the articular extremity of the bone. In this stage portions of the cartilage may be found still adherent to the bone beneath, and the margins of the articular surface usually continue to present remnants of the cartilage after it has completely disappeared elsewhere. A

somewhat different series of events is observed when the cartilage becomes secondarily affected from a primary deposit of tubercle in the synovial membrane. Here, at the margins of the cartilage, a congestion occurs, and

a layer of granulation tissue develops on the surface of the cartilage; this may proceed to the formation of fibrous tissue. Histological tubercle occurs in this granulation tissue, and gradually, by a process similar to that already described, the inflamed cartilage becomes the seat of tuberculous deposit and finally is destroyed. It would appear, from the researches of many observers, that the cartilage is never the primary seat of tuberculous disease. This is true for hyaline cartilage, but it is possible that primary tuberculous infection may occur in fibro-cartilage, as Kocher has described in the semilunar cartilages of the knee joint. It may now be added that the disease may occur primarily in synovial membrane, and then, having invaded the cartilage, the underlying bone may in turn undergo tuberculous change; and thus beneath a patch of diseased cartilage we may find inflamed and softened bone, or a portion of cancellous tissue exhibiting caries, which focus of infection is surrounded by a layer of condensing osteitis, and this in turn by rarefying osteitis.

It is quite remarkable that the condition of rarefying osteitis should be so marked at quite a distance from the actively growing tubercle, and yet we find here a manifestation in bone which is comparable to the non-infective inflammatory process which, as we know, surrounds tuberculous deposits in the soft tissues of the body, *e.g.*, in a tuberculous lymph node. Moreover, as Cheyne has pointed out, in many cases a layer of comparatively normal cancelli separates the carious part from that where the rarefying osteitis is most marked.

The extent of the atrophy of bone in tuberculous arthritis is often remarkable, and is due, no doubt, to the same causes which produce the atrophy of the muscles; the nutrition of the whole limb about a tuberculous joint is profoundly affected. Fig. 249 represents the femur of a child who suffered from hip-joint disease, and Fig. 290 is an *x-ray* picture from a case of disease in the knee joint showing marked atrophy of the bones of the leg and of the thigh.



FIG. 249.—Extreme Atrophy of the Femur in a Child whose Limb had been Amputated for Tuberculous Disease of the Hip. Original.

In considering the changes which occur in tuberculous affections of the bones at points far distant from the joint, reference may be made to the fact that tuberculous disease may manifest itself immediately beneath the periosteum, constituting a form of chronic periostitis which may lead to extensive destruction of bone. This is the form which is so familiar in the ribs, where the trouble spreads beneath the periosteum and occasionally leads to extensive and often multiple foci of tuberculous deposit, perhaps restricted to one rib, but frequently several ribs are so attacked in the same individual. Then again, the disease may begin in the medulla of the bone, constituting a tuberculous osteomyelitis. This is found in young children at times in the form known clinically as "strumous dactylitis." The processes are the same as those described, and they result in a thickening and enlargement of the bone (*e.g.*, in the phalanx), with deposit of new bone under the periosteum. The effect of this is to produce a characteristic fusiform enlargement of the bone, giving it the appearance as if it were ballooned out and suggesting the name, which older authors gave it, of "spina ventosa."

The term "caries sicca" has been applied to an unusual form of tuberculous disease in the joints. It chiefly affects the shoulder joint, but sometimes occurs in the hip and more rarely in the knee. (Cheyne.) There is no swelling such as usually appears in tuberculous joint disease of the ordinary type, but on the contrary all the structures about the joint show an increasing and progressive atrophy. The peculiarity of the disease is the formation of new tissue, which shows a great tendency to shrink and to form dense fibrous tissue (Cheyne.) It results eventually in destruction of articular cartilage with obliteration of the joint cavity and firm ankylosis of the joint. Pain is usually severe, but there is, as a rule, no rise of temperature, and there is seldom suppuration.

Among the rarer forms of tuberculous bone disease Cheyne describes "diffuse condensation of bone in connection with tuberculous disease." In a typical case in the femur he describes the following sequence of events: "A tuberculous deposit formed near the surface of the external condyle of the femur and led to the production of a sequestrum. Around this deposit condensing osteitis occurred and extended over the bone for a considerable distance, but before long fatty degeneration of the inflammatory products took place and reached an extreme degree, and calcareous salts were also deposited in this fatty material. Where this degeneration extended quite up to the cartilage the latter was deprived of nutritive material and became rubbed or broken away at the surface. The obstinacy of these cases is thus due to the fatty degeneration of the tissue and not to the tuberculous infiltration of the bone."

The same author describes diffuse softening of bone in which the very opposite condition to that just mentioned exists. The osseous trabeculae in the

epiphyses and in the medulla of the bone are destroyed; the medullary cavity is enlarged and filled with red marrow in which tubercles are found in considerable numbers. There are apt to be multiple lesions present, so that several bones are affected, and general tuberculosis is likely to supervene. The condition is a rare one.

Tuberculous Abscess (Chronic Abscess).—Abscess formation may result from the development of tuberculosis in the tissues. The sequence of events is easily accounted for. At first the tuberculous lesion manifests itself by the production of isolated tubercles; these become grouped, and, as they tend to undergo retrogressive changes, the tubercles toward the centre of the group become caseous. The invasion of the surrounding tissue by the tubercles as process continues, and the area of disease gradually increases. In the centre of the caseous mass liquefaction occurs. This is apparently due to an effusion of serous fluid which finds its way into the necrotic centre from the surrounding area of congested and inflamed tissue. The fluid which thus invades the necrotic centre is accompanied by leucocytes, but these are not nearly as numerous as those found in the pus of an ordinary septic abscess. We may now imagine that the process still further advances and the abscess enlarges. This is accomplished by further spread of the actively growing tubercles at the circumference, the older tubercles in turn becoming necrosed and fatty and forming a layer of caseous material immediately internal to the newly formed tubercles at the circumference. The central cavity enlarges, the pus increasing in amount. This pus contains, in addition to leucocytes, an amount of necrotic debris that has become freed from the caseous material which forms its immediate surroundings. The picture which presents itself is that of a mass of disease developing in the tissues, with pus at the centre surrounded by caseous material, and this in turn surrounded by tissue containing tubercles. Add to this the halo of non-infective inflammation which immediately surrounds the whole diseased area, and we find that we can distinguish well-defined zones in the affected tissues. These zones, from within outward, would consist of: first, a central zone of pus containing a few leucocytes and more or less necrotic debris; second, a zone of caseous material; third, a zone of actively growing tubercles; fourth, a zone of inflamed tissue (*vide* Fig. 250). In the fourth zone described we find that the process of inflammation may go further than merely the production of granulation tissue, for we find that, as the abscess enlarges, there is developed about it a very definite and frequently much thickened wall of fibrous tissue: the fact being that the chronic inflammatory process has gone on from the production of granulation tissue to that of fibrous tissue, so that a well-defined abscess wall is formed. As this abscess spreads, it does so by a very definite method. The newly formed fibrous-tissue investment is readily invaded by the formation of new tubercles within it, and the fibrous tissue thus disappears, while a new and more extensive area of inflam-

mation invades the tissue at the circumference. Fresh necrosis of tubercles occurs toward the centre, and the inner zone of caseous material becomes detached and partly absorbed, and an increased amount of fluid accumulates.

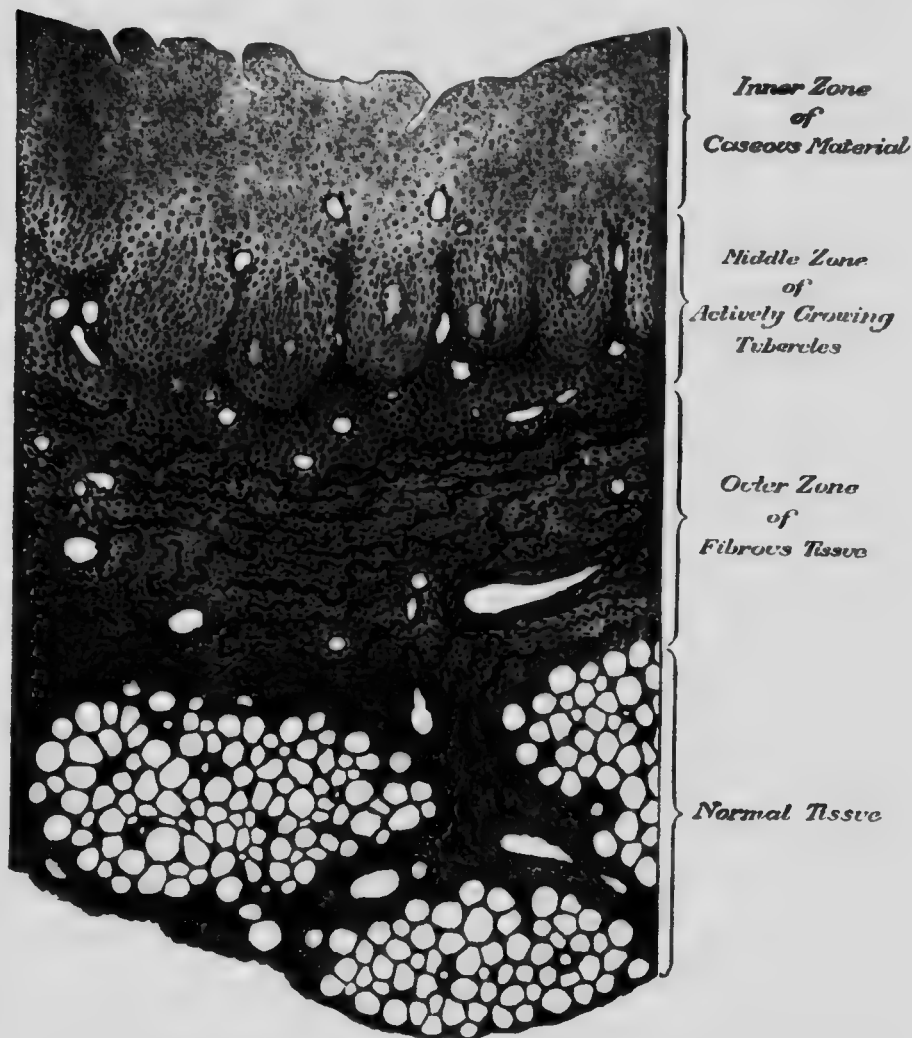


FIG. 250.—Section through the Wall of a Tuberculous Abscess. The specimen from which the section was made was removed from a tuberculous abscess which developed in connection with disease of the knee joint. A photograph of the case is shown in Fig. 294. The portion of the wall removed lay immediately under the incision made when the abscess was opened, and thus constituted a part of the abscess wall farthest removed from the diseased bone. (Original.)

Thus it is that the wall of an abscess of this character exhibits at any point of section the various layers described, and the author has frequently demonstrated this to be the case. A somewhat interesting comparison may be instituted between the zones described and those of the histological tu-

bercle, in which we have the central zone consisting of the giant cell with its many nuclei, then the zone of epithelioid cells, surrounded by the zone of leucocytes and the area of inflammation. The circumferential zone of inflammation is no doubt due to the same cause in both instances, namely, the reaction of the tissues to the presence of an irritant: in the one case the presence of a tubercle, or a group of them; in the other the presence of a larger or smaller mass of diseased tissue constituting the more complicated and probably more extensive structure of the developing tuberculous abscess.

These processes may be studied in osseous tissue modified somewhat by the nature of the bone structure, and thus we may have chronic abscess in the bone itself. (*Vide* Fig. 254.) These abscesses are frequently found in tuberculous joint disease invading the cancellous tissue. They tend, however, eventually to come to the surface, and may thus extend to and invade the joint cavity after destruction of articular cartilage has been brought about. It is not uncommon for these abscesses which have their origin in bone to find their way to the surface of the bone beneath the synovial membrane or the periosteum and then to continue to spread in the soft tissues. The spread of such an abscess may be continued to an unlimited extent as it increases in the soft tissues. It tends, however, to spread in the direction of least resistance, and is found to develop along fascial planes or between muscles. A well-known example of this is found in the psoas abscess, with which we are so familiar, which spreads under the psoas fascia until eventually, from an original focus of disease possibly far up in the dorsal spine, the abscess, passing under the internal arcuate ligament, continues its course downward under the psoas fascia until eventually it may point in the thigh below Poupart's ligament.

An abscess of this character may be extremely slow in its development, so that occasionally one has had such cases under observation for months while the increase in size has been very gradual. Such abscesses tend, however, eventually to come to the surface and may point and rupture spontaneously. On the other hand, the author has known them to disappear spontaneously. In this connection may be cited the example which was afforded the writer in a case of tuberculous disease of the dorsal spine in which laminectomy had been performed to relieve paraplegia. At the operation an abscess was found to have opened into the spinal canal and was pressing upon the cord. The abscess extended into the posterior mediastinum, and, as one could not evacuate it, an attempt was made to drain it. The contents of the abscess were fluid at the time, as evidenced by the fact that respiratory movements produced an ebb and flow of the pus as it presented itself in the neural canal. The patient died six weeks after the operation, of tuberculous meningitis. At the autopsy the abscess cavity was found in the posterior mediastinum filled with necrotic material, but no pus; a culture proved this to be sterile. The course of this case would suggest the possibility that tuberculous abscesses, when they

undergo spontaneous cure, go through changes which would be represented by a sequence of events beginning with an absorption of the fluid contents, and subsequently characterized by a disappearance (by absorption) of the debris, which in turn fills the cavity, the tubercles in the mean time ceasing to multiply and the disease thus becoming quiescent.

A typical case of tuberculous abscess is shown in Fig. 294. The abscess developed in a child of six years of age; it was situated to the inner side of the knee and was opened under aseptic precautions, healing taking place by first intention. The case illustrates the formation of an abscess that came to the surface outside the joint, and in no way implicated the joint cavity nor restricted the movements of the joint. The piece taken out for microscopic section (shown in Fig. 250) was excised at a point as far removed from the bone as possible and represented the wall at its most superficial part, and yet we find the typical zones of the abscess wall here represented.

Changes in the Ligaments about a Tuberculous Joint.—The ligaments become the seat of an inflammatory process which at first is non-infective in type. The result is that the ligaments become soft and yielding and permit dislocation of the joint in varying directions. This, for example, is very noticeable at the knee, where we often find dislocation backward of the head of the tibia with rotation of that bone outward. The deformity is produced by the action of muscles. The stability of the joint is impaired by the implication of the ligamentous structures in the inflammatory process, and then dislocation becomes possible and readily occurs. In long-standing progressive disease the ligaments may themselves become the seat of tuberculous lesions and may become destroyed.

Changes in the Muscles About a Tuberculous Joint.—One of the most characteristic phenomena which may be observed in connection with tuberculous joint disease is muscular atrophy. This is so marked a feature that in a suspected case, if we are unable to determine the existence of muscular atrophy, we may practically exclude tuberculous disease in our diagnosis. The cause of this atrophy is often attributed to disuse of the affected limb, but we cannot always explain it thus. In the earlier stages of tuberculous joint disease the muscles controlling the movements at the affected articulation are not in a condition of rest; on the contrary, they are more or less constantly in a condition of tonic contraction and are always on the alert to protect the joint from movement. Otherwise expressed, we may say that the muscles are active agents in maintaining the fixation of the joint. In spite of this fact the muscles atrophy. The probable explanation of muscle atrophy in tuberculous arthritis is to be found in some nerve influence (possibly reflex) that interferes with the nutrition of the muscles of the limb in which the joint trouble is located. The

use diminishes in bulk, and the contractile elements are replaced by fat and fibrous tissue.

Prognosis.—The possibility of effecting a permanent cure in tuberculosis is a question which has received much attention from time to time, not only in connection with tuberculous diseases of the bones and joints, but also in similar affections of the lungs and other organs of the body.

The disease may remain quiescent for many years, as in the case already referred to in this article (page 567), where tuberculous hip trouble was dormant for eighteen years and then reasserted itself. Nevertheless, numerous instances exist where the disease has ceased and the individual has subsequently lived for many years without any further manifestation of the tuberculous affection. It is probably incorrect to say the disease was "dormant" in a case of recurrence, because the idea conveyed by such a phrase would not be quite consistent with the facts as we know them. Take, for example, the case of hip-joint disease which has been arrested after two or three years of treatment by rest; we may assume that in such a case the destruction of tissue has been great and a cure has eventually been effected largely by the substitution of fibrous tissue for tuberculous tissue. Now this scar tissue, if we may call it so, is more likely to become infected by a fresh inoculation of tubercle than normal tissue, and hence, under favorable conditions, the individual may have a recurrence of the disease in the region previously attacked. With this understanding of the results obtained, one may hold that it is quite correct to speak of a cure, and we may imagine that the disease may be entirely eradicated from the system, but we must also recollect that the individual who has once had tuberculous joint trouble is predisposed to a subsequent attack and must therefore adopt suitable measures for protection against such an attack.

It would appear, however, that there is a condition in which we are justified in speaking of the disease as having become quiescent. Encapsulation of a tuberculous deposit may take place, and it has been shown that such deposits may continue to contain the active tuberculous virus—*i.e.*, the bacilli. Caseous material, too, may become infiltrated with calcareous salts, and these deposits very frequently possess the active tuberculous virus.

In early cases of joint tuberculosis we often succeed by treatment in getting excellent results with a minimum amount of damage to the tissues. If the case is seen early and treatment by prolonged rest is carefully carried out for a long period, we may succeed in effecting a cure without any deformity or impairment of the joint function. In such cases we may suppose that the infective material has been entirely eradicated from the tissues, and that there is not the same danger of recurrence because a minimum amount of fibrous tissue has been formed.

The conditions under which the bacillus of tubercle thrives are difficult

to reproduce in the laboratory, and while, under certain circumstances, the tissues of the body may supply a suitable nidus for its growth, yet it would appear that the necessary conditions may be upset and the virus cease to flourish. Comparatively speaking, the human tissues do not form a suitable environment for the development of tubercle. The susceptibility of various animals to tuberculosis varies greatly. Thus the guinea-pig falls an easy prey to a minute dosage, while, on the other hand, the dog is not easily inoculated. Experimental evidence also goes to show that in an animal, such as the dog, which is not easily affected, tuberculosis tends to be restricted to local manifestations and does not tend to become disseminated generally. In man this is also the case and by far the most frequent manifestations of tuberculosis are in localized areas, while general miliary tuberculosis is comparatively rare. Cheyne found remains of tuberculous material in the tissue about a joint in which fibrous ankylosis had taken place, and he alludes to the danger of breaking down such a joint forcibly lest the disease be lighted up again. It is a familiar circumstance that fresh disease may light up after manipulation of a joint which has been the seat of old-standing disease.

The constitutional and local conditions which affect the growth and development of tubercle in the tissues, and hence the prognosis in existing disease, may be referred to in this connection. The "constitution of the patient" may predispose to tuberculosis. We have already considered heredity, and we may note that children of tuberculous parents may contract tuberculosis because of some inherited type of development which results in a diminished power of resistance, but it is obvious that the children of such parents may contract the disease from an infected parent or may fall victims to it because they are living under conditions similar to those of the parents, and these home surroundings may be responsible for inducing disease quite apart from hereditary taint. Such conditions as bad food, ill ventilation, exposure to cold and wet, etc., may be shared alike by the parents and children, who may also share in the development of tuberculosis. Where such an environment exists, the prognosis in tuberculous disease is undoubtedly not so good as under more favorable surroundings. Climatic conditions are also factors affecting the spread of tuberculosis. There are certain diseases which appear to predispose to tuberculosis, or in some cases to aggravate the tuberculous condition which may be present. Thus, measles may be followed by strumous lymph nodes in the neck, or tuberculous joint disease; so, too, may scarlet fever, whooping cough, etc. Of the local conditions affecting the occurrence of tuberculous joint disease we have referred to injury; this may also affect the course of an existing disease. Cheyne holds that the virulence of the bacillus itself is a factor, as the virulence varies in different cases; no doubt, too, the dosage has a marked influence in many cases. All these factors necessarily affect the prognosis. Lastly, in this connection the occurrence of sepsis has undoubtedly a marked effect on the prog-

ness of the disease. This fact is perhaps most clearly demonstrated if we compare the way in which a tuberculous abscess disappears when we succeed in getting it to heal by first intention after opening it and evacuating its contents and finally stitching it up without drainage under efficient aseptic conditions, with the condition of affairs which supervenes when mixed infection occurs; in the latter case destructive processes rapidly manifest themselves and an entirely different complexion is given to the case, necessitating a much more serious outlook.

The Treatment of Tuberculous Joint Disease.—Treatment may be considered under two headings: first, the constitutional, and, second, the local measures which may be indicated.

CONSTITUTIONAL MEASURES.—Tuberculous patients must be placed under proper hygienic surroundings. It must be remembered that spontaneous cure is possible in many cases of joint tuberculosis, and that certain conditions favor the production of that spontaneous cure, while other conditions militate against it. Further, while we are adopting definite measures for the local treatment of the trouble, we must also secure for the patient careful attention to his general state of nutrition, for the latter reacts most markedly on the course and progress of the local disease. These indications have been stated to be fulfilled by placing the patient in surroundings most favorable for the maintenance of a maximum degree of nutrition, and by taking such measures as, in a local or general way, influence the tuberculous processes. (Osler.) The principle involved in the *open-air treatment of pulmonary tuberculosis* is important here, and there can be no doubt of the importance of securing, if possible, similar conditions in the treatment of joint tuberculosis. The great advantage of this treatment is annually demonstrated in Toronto, where the Hospital for Sick Children (one hundred and fifty beds) transfers all its patients to summer quarters (the Lakeside Home) every year. They are provided there with a hospital at Toronto Island, on the shore of Lake Ontario. The summer hospital is provided with extensive veranda space, so that the patients may enjoy the maximum amount of sunshine, may sleep in their cots in the open air, and thus may remain constantly in an atmosphere which is pure, and of a fairly equable temperature. The beneficial effects of these surroundings are most obvious; children suffering from joint tuberculosis in all stages are markedly benefited, and it is not unusual to watch with anxiety a serious case of tuberculous arthritis toward the end of the winter in the hospital in the city, in the hope of tiding the patient over the necessary time until he is able to be transferred to the Lakeside Home, where one has every confidence that he will be benefited. The question of climate is to be discussed from the same standpoint. This subject cannot be treated here at any great length, but one may say that the main objects to be attained in any climate are those which we have referred to, namely, to see that the atmosphere is pure;

and for that reason cities and towns are to be avoided, if possible, and country districts preferred. Sudden changes in temperature are baneful and must be avoided, and the maximum amount of sunshine should be secured. These are the considerations which should guide us in the choice of a suitable climate. Where it is impossible to send the patient away from home, then an effort should be made to secure the necessary conditions in the home or in the hospital. Ventilation of the room or the hospital ward must be efficient. In cold climates patients should be taught that pure air in a room is much more important than warm air, and they should learn that it is possible to keep the body warm in a cold atmosphere by suitable clothing; the bedroom window should be open at night and the patient should live as much as possible in the open air.

Good, nourishing food is another essential. This must be provided of the character and amount which can be assimilated by the patient. The appetite may be stimulated by the administration of a bitter tonic. Bidder's suggestion that the foods should be rich in soda and fat, and excess of vegetables avoided, may be found worthy of adoption.

The *administration of certain drugs* may be of service. Cod-liver oil is of value in tuberculous arthritis; in pulmonary tuberculosis its action is said to be less certain. A teaspoonful thrice daily after meals should be given. The hypophosphites are useful tonics and may be given with advantage. The combination of the syrup of the iodide of iron with cod-liver oil has long been recognized as of value. Arsenic is also of service; there is no general tonic more satisfactory in cases of tuberculosis of all kinds than Fowler's solution. (Osler.) The value of tuberculin as a specific form of treatment for joint affections will be discussed more in detail presently (page 592); if some of the more recent investigations are as successful in establishing facts which would show beneficial results as they appear to promise, then we may hope that in the future this treatment will be employed with great advantage.

The nutrition of the body is improved by *exercise*, and hence we must bear in mind the necessity of combining properly regulated exercise with our treatment where that is at all possible.

LOCAL TREATMENT.—*Rest* of the diseased articulation is a most essential part of the treatment in tuberculous joint disease. This is to be accomplished by suitable splinting. The form of splint will vary with the particular joint affected, and, again, with the acuteness of the inflammatory processes which may manifest themselves during the course of the disease. Thus, if we are treating hip-joint disease in the early stage, and we find the patient to be suffering from pain and that the temperature is elevated, it is best to confine that patient to bed while the acute symptoms are in evidence. On the other hand, when the inflammatory symptoms have subsided and the disease has become quiescent, we must permit the patient to get about and to take exercise. It is ob-

vious that some special form of retentive apparatus which may be efficient while the patient is in bed may be of little value while the patient is going about; hence it may be necessary to employ different methods of splinting in the two cases. Certain forms of splint which we shall describe later are of service both as bed splints and as splints with which the patient goes about.

An important principle to have in mind when we thus secure a limb at rest is to correct at the same time any faulty position of the limb which may have been assumed. In view of the fact that tuberculous joints may become stiff or even ankylosed as the disease progresses, it is wise to see that rest for the articulation is secured with the limb in such an attitude that should stiffness occur the limb will be fixed in the position which will subsequently be most serviceable. Thus the ankle should be splinted so that the foot is at a right angle with the leg. Flexion at the hip or knee must be corrected; the elbow should be flexed and the forearm placed in a position half way between pronation and supination, etc.

Many different materials have been used for splinting purposes. Plaster of Paris is of great service and may be used extensively in the treatment of tuberculous arthritis. The knee or ankle may thus be most efficiently splinted by encasing it in plaster. So, too, the hip may be fixed by the application of a plaster spica (see Fig. 269). The joints of the upper extremity may also be secured by means of plaster bandaging. Special splints are devised for different articulations and may be made of leather, poroplastic material, steel, etc. These will be described when we come to deal with the individual joints.

The effect of rest is to permit a subsidence of the inflammation. While in the broadest sense we must consider inflammation as the attempt on the part of nature to repair injured or diseased tissues, yet it is obvious that rest is necessary in order to make sure that inflammation shall not lead to destructive processes. The effect of unrest is to maintain and increase the inflammatory reaction, and we know that such a process may have a baneful effect. The exudate may be excessive and the wandering cells may themselves become destroyed. We have already seen that the tuberculous process readily invades tissue which has become the seat of a chronic inflammation and in which there has been the development of granulation tissue or even of fibrous tissue (*vide* page 574); and so it becomes necessary to keep these parts at rest and allow the inflammation to subside. Pain is an excellent splint and it is by means of this symptom that nature demands rest for an injured and inflamed part, but the promptings of nature are frequently not sufficiently urgent in this regard in tuberculous disease, and therefore we must the more be on our guard to see that rest is provided.

Traction.—This is merely a means of securing rest and is a most valuable one. The usual way of securing traction in the lower extremity is by means

of the weight-and-pulley apparatus such as will be illustrated in describing the methods employed in dealing with the individual joints. The object of employing traction is to remove the cause of unrest, which is produced by the tonic contraction of the muscles about the inflamed joint. When these muscles contract they press together the inflamed articular surfaces and thus cause pain and maintain the inflammation. Great relief is experienced, by patients suffering pain in a tuberculous joint, when traction is applied. The amount of weight need not be great; the constant steady traction of a small weight will soon tire out powerful muscles and overcome the pressure exercised by their contraction upon the joint surfaces. Traction is, of course, of most value in disease of bone or cartilage and is not so notably effective in synovial disease, although it has a beneficial influence here too. Traction, also, is of service in correcting the faulty attitude of the limb, as will be illustrated more particularly in treatment of the hip and knee.

Counter-irritation.—The action of a counter-irritant is to bring about a reflex contraction of the vessels in the inflamed tissues. Thus a blister may be applied over an inflamed knee with good effect; the superficial vessels are dilated visibly, producing a reddening of the skin, and the deeper vessels are contracted, and thus pain is relieved. One finds in tuberculous arthritis that such measures are seldom called for, as the inflammation subsides with rest and extension quite satisfactorily.

The actual cautery has been used for counter-irritation with good effect in tuberculous disease, more particularly in the hip, the shoulder, and the spine.

Scott's dressing, composed of compound mercurial ointment spread on chamois leather, is cut in narrow strips and applied firmly, say, over the knee joint; one strip being made to overlap the other, as is done in strapping a joint in the ordinary way. This dressing, which has long been used in chronic inflammatory processes will be found of value in tuberculous arthritis. It combines the effect of a counter-irritant with that of firm pressure.

Injection of Iodoform Emulsion.—This consists of the injection of iodoform emulsion in glycerin directly into the joint cavity. The method of its employment may here be described, as it has been so widely used. It is well to remember that the preparation is not powerfully antiseptic, and in fact the iodoform may not be sterile; consequently great care must be taken to insure that the material shall be sterile before it is used. The method of preparing it recommended by Cheyne is as follows: The iodoform used for the emulsion should be allowed to stand submerged in a five-per-cent watery solution of carbolic acid for at least forty-eight hours, the bottle being frequently shaken so as to insure the free access of the acid to the powder. Instead of using glycerin alone, it is well to add one two-thousandth part of perchloride of mercury to it. The iodoform is strained from the carbolic acid, and is mixed with the glycerin in the proportion of ten per cent. The emulsion

should be put in a sterilized bottle and allowed to stand for another twenty-four hours before it is used.

The method of injection consists in taking a syringe of suitable size, plunging the needle directly into the joint cavity, and injecting the emulsion. The total quantity used should be accurately measured because there may be some danger of causing iodoform-poisoning as well as toxic effects from the glycerin. In children, from one to four drachms may be safely used, and in adults as much as half an ounce. Part of the material may be advantageously injected into the thickened synovial membrane at several points as well as into the joint cavity. After the injection, the joint swells up in consequence of effusion into it, but this swelling goes down in two or three days. The injection is repeated once a week and persevered with until the joint has sufficiently recovered, or until it becomes evident that the treatment is no longer doing any good. The injection of iodoform emulsion into tuberculous joint cavities is of doubtful value and by some is held to be positively injurious. In the Hospital for Sick Children, Toronto, it was given a fair trial, but is now no longer used.

Operative Measures.—The treatment of joint tuberculosis by operative means constitutes a method of dealing with these cases which occasionally becomes necessary. Definitely localized tuberculous foci in bone may be excised. Now and then it may be possible to resect a focus in the articular extremity of a bone without opening the joint cavity. The excision of a tuberculous joint is sometimes called for, or, short of that, the joint may be opened and all infected tissue carefully dissected away, as in the operation called "excision" or "arthrectomy." Amputation is rarely called for, but may become necessary where it is hopeless to attempt to save the limb and where life is endangered. Where septic sinuses exist, these must be dealt with, and tuberculous abscesses usually demand operative interference. The indications for operation and the various methods suggested will be discussed fully in connection with the various joints.

Local Hyperæmia as a Therapeutic Agent.—A method of treatment known as "the Bier treatment," because introduced by Professor Bier, of the University of Bonn, is one in which hyperæmia is utilized as a therapeutic agent; this is mechanically induced by stasis. The technique of this procedure may be described as follows: A so-called "cured" or elastic woven rubber bandage is applied around the limb above the affected joint; the bandage must not be restricted to a limited area, but must be spread over a considerable portion of the limb, the reason being that it is difficult to attain the desired degree of hyperæmia if the various turns of the bandage cover one another and thus encircle the limb over a restricted segment only. The bandage must be applied firmly enough to produce a vigorous stasis hyperæmia. The subcutaneous veins distal to the bandaged part will swell markedly, the skin becomes bluish-red, and at the end of about an hour a slight prickling sensation will be

experienced by the patient. The portion of the limb distal to the affected joint is not bandaged. It is not necessary that the bandage should be applied close above the affected joint; thus, in tuberculosis of the wrist or of the ankle joint, the bandage may be applied around the upper arm or the thigh respectively if for any reason one would rather not apply it immediately above the joint. The stasis induced should never produce pain. It would appear that in some cases pain may be produced, and, if so, then the method of treatment should be abandoned, as it is likely to do harm. One must remember, however, that pain may be caused by faulty technique; under no circumstances, therefore, must the patient be allowed to suffer pain from the treatment. Another precaution to bear in mind, and one, too, which aids us in determining the degree of hyperemia to be attained, is that the temperature of the limb distal to the bandage must not be rendered cold by the process. The limb must not become colder to the touch than its fellow of the opposite side. On the contrary it is often possible to induce an elevation of temperature in the affected limb; in fact, it is considered most favorable if the temperature of the affected joint thus rises during the treatment. The bandage must not be applied for a longer period than one hour daily. The duration of treatment is regulated by the progress made by the patient; it is continued until pain and swelling have disappeared and until free movement of the joint is attained—until, in fact, a cure is effected. Most of these cases of tuberculous arthritis require treatment that extends over some months; it is not unusual to continue it for a year or even longer. Frequent intermissions of treatment of, say, eight days are found advisable. If a tuberculous abscess exists when the patient is put under treatment, it is opened and the pus evacuated, and from one to three days must elapse before stasis hyperemia is instituted. Should such an abscess develop during treatment it is evacuated and the treatment postponed for a few days. Should the tuberculous abscess be of large size, it is well to wait until the wound has healed before producing the hyperemia. Sinuses frequently close under the treatment; care must be taken to remove sequestra of bone, which may be the cause of the persistence of sinuses. Tuberculous ulcers, too, it is claimed, improve under treatment. The joints are not kept at rest during treatment; on the contrary, the patients are encouraged to use the affected joints as long as there is no pain. While pain persists, however, it is prudent to keep the joints at rest. At the same time it should be stated that some degree of caution should be used so that the patients may not strain the affected joints by heavy work; walking, in affections of the lower extremity, is often possible without discomfort, and then should be encouraged in moderation; care should be taken to prevent the production of flat-foot in diseased tarsus. Exercise is not permitted while there exist tuberculous ulcers, abscesses, or sinuses. By such means it is claimed that this form of treatment results in the preservation of functionally useful joints, while other con-

servative forms of treatment in which rest is essential bring about a cure with the joint stiff and functionally useless. In a certain proportion of cases it would appear that the Bier treatment is unsuitable, and, when improvement does not take place after a fair trial, then this method of treatment should be abandoned. It is also useless to attempt this treatment where cases come under observation with such a degree of deformity that resection is necessary. Further, the Bier treatment should not be attempted in the presence of very large tuberculous abscesses, or where there is hydrops articuli.

It is claimed that by the Bier treatment certain very definite results are attained which have a beneficent effect upon the progress of the case. In the first place, the analgesic effect is most striking and of importance as a feature of the clinical course, affording much relief to the patient. A further effect of the hyperæmia is rapidly to diminish and abolish pain. Within an hour this result is often attained. The abolition of pain, in turn, prevents the reflex contraction of muscles, and the joint becomes mobile and is no longer fixed. Deformity due to faulty position and ankylosis is thus prevented.

Hyperæmia, too, is said to have a bactericidal effect. This is explained in a variety of ways: (a) It may be accounted for by the increased number of leucocytes leading to a destruction of the bacteria through their agency; (b) the products of the metabolism of the bacteria may be retained, and thus self-destruction is brought about (a sort of tuberculin effect); (c) it may be through a concentration of the bactericidal power of the blood at the seat of the infection; (d) the blood may be more actively bactericidal because of its increased alkalinity; (e) lastly, it may be that Wright's theory as to the increase of the opsonic index may be explanatory of the effects produced upon the bactericidal quality of the blood under such conditions. There is, too, an absorptive effect produced by hyperæmia. This is most noticeable in the active hyperæmia which is produced by hot air; this will rapidly remove the œdema, which is temporarily induced by passive hyperæmia in the Bier treatment of tuberculous joints; further, not only does the œdema subside after the bandaging treatment, but absorption occurs, so that the swelling which was present before treatment was initiated disappears. Bier would have us believe that there is a solvent action produced, so that the greater part of the diseased granulations and the adhesions in the stiff joint are converted into substances soluble in water and are then absorbed by the blood. Lastly, a nutritive effect is produced by hyperæmia. Regeneration of tissue is promoted by both active and passive hyperæmia. These regenerative effects can be observed by comparing a skiagraph taken after treatment with one taken before treatment was begun. In the latter the outlines of the bones are indefinite and indistinct and their shadows light, while in the former these outlines are much improved; they become distinct and definite and the shadows more dense.

The Tuberculin Treatment.--The treatment of tuberculous arthritis by means

of Wright's opsonic index and Koch's tuberculin promises to constitute an important addition to scientific surgery. The basis upon which the treatment by Wright's method is carried out must be referred to in order that the objects aimed at in the treatment may be understood. Wright and Douglas, of St. Mary's Hospital, London, studied the phenomenon of phagocytosis in 1903. They found that leucocytes separated from the blood stream and suspended in a neutral medium were incapable of any phagocytic action when mixed with an emulsion of staphylococci, but the addition of blood plasma or blood serum had the effect of immediately inducing phagocytosis. These results showed that the leucocyte itself was incapable of phagocytosis, except in the presence of blood serum or blood plasma. By special methods of experiment they determined that the blood plasma contained an element which acted upon the micro-organisms and so affected them that the leucocytes were now able to destroy them by phagocytosis. The substance in the plasma which thus prepares the micro-organism for the action of the leucocyte was called an "opsonin" (from *opsono*, I cater for, I prepare victuals for). The opsonins are supposed to be carried in the lymph stream to the bacteria which have invaded the tissues, and there the opsonins chemically combine with the bacteria. It is only after the bacteria have combined with the opsonins that the leucocyte is capable of carrying on its rôle of activity in the phenomena of phagocytosis. The leucocyte does not appear, therefore, to assume the active rôle in phagocytosis that had previously been assigned to it. Urwick takes an advanced view when he states that "their use may be compared to the use of culture media in bactericidal experiments to estimate the number of bacteria which have been destroyed."

If normal serum is heated to 60° C. for ten minutes the opsonins are completely destroyed. It has been shown that the opsonins are distinct from bacteriolysins, agglutinins, and antitoxins. The opsonins also have a high degree of specificity; thus the blood of a person may contain half the quantity of opsonins necessary to combat effectively a tuberculous affection, *e.g.*, a tuberculous cystitis, and yet contain a normal amount of opsonins that have to do with an invasion of staphylococci such as causes furunculosis. (Ross.) It would appear that the phagocytic action of the leucocyte is a constant factor. Thus leucocytes separated from the plasma of an immunized individual would show the same degree of phagocytic action when mixed with an emulsion of staphylococci as would the leucocytes similarly separated from the blood of a normal individual. But should one add the serum of an immunized individual to the mixture of leucocytes and staphylococci, then the amount of phagocytosis would be one-half greater than that which would take place were the serum of a normal patient substituted for that of the serum of an immunized patient. So far as we can tell at present, plasma has nothing to do with the "quality" of the leucocyte. (Ross.) It appears that the degree of phagocytic activity of the

leucocyte is in direct proportion to the amount of opsonins present in the plasma.

The application of these facts to the practical treatment of tuberculous affections is brought about by determining the opsonic power of the patient's blood, and then using therapeutic means to increase that power and thus augment the bactericidal quality of the blood.

The technique employed by Wright is as follows: We must first of all obtain equal quantities of—

(a) The patient's serum.

(b) Blood corpuscles washed in a solution of one-half per cent sodium citrate in normal salt solution.

(c) An emulsion of tubercle bacilli.

A drop or two of blood from the patient will be sufficient to give us the necessary quantity of serum. The source of the corpuscles may or may not be from the patient, they may be drawn from a healthy person; the result will be the same, for reasons which we have already explained. Equal quantities of (a), (b), and (c) are drawn up into a capillary pipette; this is sealed and placed in an incubator for twenty minutes at 37°C .; films are made of the mixture, and these are stained in the ordinary way for tubercle bacilli. The average number of tubercle bacilli ingested by each polynuclear white corpuscle is then calculated by counting a definite series of these, and the figure thus obtained gives us an index of the phagocytic activity of the leucocytes. In order to institute a standard for comparison we must carry out another experiment, substituting, however, the serum of a normal individual for that obtained from the patient. Thus, we obtain what is called the "phagocytic index" of the patient, and we compare it with the "normal phagocytic index" of a normal individual. For example, the average number of bacilli found in the tuberculous patient under observation may be 2 (phagocytic index) and that in the normal individual 4 (normal phagocytic index); the actual ratio being 2 : 4, or 0.5 : 1.0. We would then speak of 1.0 as the normal "opsonic index" and 0.5 as the "opsonic index" of the tuberculous patient.

It is necessary that the standard serum and the serum from the patient must be withdrawn within a few hours of the same time, because the opsonic power of serum after it has been withdrawn from the body gradually diminishes.

In localized infections the opsonic index is found to be below normal, but in systemic infections the opsonic index is a variable factor—at one time low, at another high. Thus in pulmonary tuberculosis the opsonic index has been frequently observed, as, say, 1.6, and a few days later, 0.5. On the other hand, take such a localized affection as tuberculous lymph nodes in the neck, or a tuberculous hip joint, and the opsonic index will be low continuously.

The practical application of these facts to the treatment of tuberculous

arthritis consists in employing measures to increase the opsonic index and maintain it at a high level, so as thus to augment the bactericidal quality of the blood by increasing the number of opsonins in the serum. The way in which Wright attains this end is by inoculating the patient with dead micro-organisms of the same species as that maintaining the disease. The vaccine used in tuberculosis is Tuberculin T. R., which is made from the finely triturated bodies of tubercle bacilli.

The effects produced by the inoculation of a bacterial vaccine into the tissues has been described by Wright in the following terms:

1st. Upon the inoculation of the vaccine there supervenes a period of intoxication which is characterized by a decline in the antibacterial power of the blood. This "negative phase" is more or less accentuated or prolonged according as a larger or smaller dose of the vaccine is inoculated. In the former case the "negative phase" may disclose itself to clinical observation by a temperature reaction and constitutional disturbance. In the latter the "negative phase" may be quite unaccompanied by clinical symptoms.

2d. Upon the "negative phase" there follows a "positive phase." This phase, whose characteristic feature is an increase in the antibacterial power of the blood, corresponds to a period of increased resistance. There is associated in many cases with the climax of the "positive phase" a sense of increased physical vigor and a very profound feeling of well-being.

3d. After the negative phase (which Wright has called the "ebb and flow of the tide of immunity") the blood may be maintained for a variable period (after tubercle inoculation, occasionally for as long as a month) at a somewhat higher level of antibacterial power than before inoculation. Or—and this, in connection with inoculation with tubercle vaccine, is a more constant event—the antibacterial power may over and over again fall back, after ten days or a fortnight, to the level at which it stood anteriorly to inoculation.

A study of these results suggests a plausible theory which has been put forward to explain the fact that in localized tuberculous affections the opsonic index is continuously low, while in general tuberculosis the opsonic index shows great fluctuations. In the generalized affection we find that the tuberculous patient is constantly inoculating himself: there are from time to time a greater absorption of toxins and a greater stimulus to the production of protective substances in the blood. This "auto-inoculation" in its immediate effect produces a negative phase, as in the inoculation artificially produced, but it too has the positive phase succeeding the negative and resulting in the production of a high opsonic index. Thus in these cases of systemic tuberculous affections there is a great deal of fluctuation in the opsonic power of the blood due to the conveyance of bacterial elements into the blood in irregularly interspaced doses. On the other hand, in localized affections the opsonic power is constantly low, and this is accounted for by assuming that a low opsonic index

existed prior to the tuberculous infection; then, because of the fact that the lesion is localized, there is not the same conveyance of bacterial elements into the blood that there is in the generalized affection, and hence auto-inoculation does not take place, and the opsonic index remains continuously low. Wright utilizes this theory to explain why it is that many localized tuberculous effusions do not tend to get well, but are of almost indefinite duration, as is the case, *e.g.*, in lupus.

These considerations and the conclusions therefrom may otherwise be expressed by stating that an increased opsonic power is to be expected in those cases in which there has been an active response, on the part of the machinery of immunization, to the stimulus of infection; and a decreased opsonic power is to be expected in individuals in whom there is an inherent deficiency in opsonic power or in whom the machinery is becoming exhausted. It is not unusual to find the opsonic power high in acute affections, even in localized disease. The following table from Urwick's statistics shows the low index in tuberculous joint disease. It will be noted that the acute cases Nos. 1 and 2 showed a high opsonic power:

No.	Age.	Disease.	Opsonic Power.
1.	5	Acute tuberculous disease of the hip, duration 1 month	1.20
2.	8	Acute tuberculous knee	1.30
3.	18	Tuberculous caries of the spine with abscesses for many years.	.80
4.	13	Chronic tuberculous disease of the hip joint, duration 13 months.	.30
5.	8	Psoas abscess, duration 18 months.	.40
6.	28	Psoas abscess, duration 2 years.	.80
7.	8	Chronic tuberculous disease of the hip joint, duration 4 years	.80
8.	68	Tuberculous disease of the elbow joint, duration 6 months	.50
9.	4	Acute tuberculous disease of the ankle joint.	.80

The explanation of the high opsonic index in certain of the acute cases of localized affections is doubtless found in the greater absorption of toxins which occurs in such cases, this acting as a stimulus to the production of opsonins in the blood. In the acute case, No. 9, the machinery of immunization was probably overtaxed and exhausted.

An important observation must be made regarding the cumulative effect produced by the inoculation of bacterial vaccines. Cumulation in the direction of the negative phase is always produced; but in inoculation in tuberculosis it is difficult, if not impossible, to get cumulation in the direction of the positive phase. (Wright.) For this reason Wright is content to treat each inoculation in tuberculosis as an independent event. In view of the fact that cumulation in the direction of the negative phase is a constant factor, it is essential to have frequent examinations made of the patient's opsonic power during inoculation treatment. Obviously, serious harm may be done if this caution is not observed. For example, the negative phase after tuberculin may last ten days and from clinical symptoms and signs we get no evidence of this. If in such

a case a second inoculation is given during the negative phase, evil, and not good, will result. In every case, therefore, examine the blood before inoculation. (Urwick.)

We are dealing in this article with the treatment of joint tuberculosis, *i.e.*, localized tuberculous affections. Wright's dictum regarding such is that in the treatment of localized affections it is necessary to raise the opsonic power of the blood and to keep it at a high level, and to bring the antibacterial lymph into contact with the organisms in the local lesion. The principles underlying this treatment have been outlined by him as follows:

1st. The tuberculo-opsonic power of the blood in these cases appears to be uniformly inferior to that of the normal blood.

2d. The immunizing stimuli which are required for raising the opsonic power and for maintaining it at a high level here make default.

3d. The tubercle bacilli are cultivating themselves in the focus of infection under conditions which are much more favorable to their growth than those which obtain in the case of the circulating blood.

4th. An increase of the opsonic power of the blood can be achieved and maintained by the inoculation of a series of appropriately adjusted and interspaced doses of tubercle bacilli.

5th. We have at our disposal methods by which we may increase the lymph flow through the focus or foci of infection in such manner as to bring the antibacterial element of the blood into application upon the invading bacteria.

The material used for inoculation is Tuberculin T. R., and certain precautions must be employed in regulating the dose. Wright advises that the dose to begin with should be 0.001 mg. The dose must be small because of the danger of producing a prolonged negative phase which would be the result were too much tuberculin given. The dose may be increased to, say, 4.00 mg. These doses refer to the weight in milligrammes of the tubercle powder. The machinery of immunization may be brought into action by a very small dose, and this may be very easily overtaxed, so that one must use the smallest dose that will produce a satisfactory response. (Wright.) In the case of an inoculation which is successful, the opsonic power is raised and is maintained at a higher level. The ultimate result depends on the correct interspacing of appropriate doses of vaccine. The dose is to be repeated when the effect of the first inoculation is passing off, as indicated in a decline of the opsonic index; and the dose is to be increased only when the previous inoculation has failed to evoke a satisfactory response. The effect of a second inoculation given when the positive phase is at its height will be to raise the opsonic power to a still higher level, but the effect of a second inoculation given during the negative phase will be to reduce still further the opsonic power, already reduced by the first inoculation. In both cases the effect of the inoculation may be cumulative; in the former case it is always so in the direction of in-

creased resistance, and in the latter in the direction of diminished resistance to bacterial invasion. With each dose the negative phase should become less pronounced; if it becomes more pronounced the dose is too large. The positive phase following inoculation may last a long time; thus a positive phase lasting two months has followed the inoculation of $\frac{1}{800}$ mg. (Urwick.) To repeat too soon only cuts short the positive phase and induces an accentuated negative phase.

In addition to the means here employed for raising the opsonic power of the blood, it is possible to utilize methods which send a stream of the antibacterial lymph through the focus of disease. Wright instances the empirical methods in vogue which apparently acted in this way in producing their beneficent effects: the old-fashioned poultice, Bier's method of obstructing the circulation, the use of rubefacients and iodine, the x-rays, radium, or radiant heat. All these, according to Wright, had the effect indicated. They may be used intelligently along with the inoculation treatment. In fact, if not used intelligently they may do harm, and not good. The following considerations suggested by Wright illustrate the principles which he would have us consider in employing such adjuncts to the inoculation treatment:

(a) Douching a bacterial nidus with lymph of low antibacterial properties is not unassociated with risk (*e.g.*, general infection might follow).

(b) Douching a bacterial nidus with lymph is best after raising its antibacterial properties by auto- or artificial inoculation.

(c) An ampler lymph stream may be attained after decalcifying agents (*e.g.*, citric acid) have reduced the coagulability of the blood.

(d) The injection of decalcifying agents dissolved in concentrated sugar or salt solution into discharging sinuses may possibly be found useful in increasing the irrigation of such sinuses by lymph.

(e) If the Finsen light acts by determining lymph to the seat of infection, then this result might be accomplished by cheaper and less laborious methods. Wright suggests the use of hot sterilized sand for the purpose, this being considered a very inexpensive and convenient method of determining a blood stream to any region on the surface of the body. For the sterilization of sand Wright gives the following instructions: Place the sand in a saucepan over the fire, having previously stirred in a number of small pieces of white paper. Continue the stirring until, with the attainment of a temperature of 200° C., the pieces of paper have all turned brown.

If we are to accept the theories promulgated by Wright, we have an explanation of the beneficial effects which may follow operation for tuberculous disease, even in those cases in which the surgeon has only partially succeeded in removing the focus of disease. This phase of the question is dealt with by Wright when he says, regarding operations, that "they may be followed by the whole train of events which we have learned to associate with the inoculation

of a bacterial vaccine." So, too, he claims that exercise may be an active agent in connection with the production of immunity, and massage may produce effects similar to that of inoculation.

II. TUBERCULOSIS OF INDIVIDUAL BONES AND JOINTS.

Tuberculous Disease of the Bones of the Skull.—*The mastoid process of the temporal bone* is more frequently the site of tuberculous disease than any other bone of the skull. Its appearance there is associated with disease of the middle ear. Pyogenic infection is prone to occur, and then serious complications may result from extension of the septic processes to the lateral sinus or the meninges of the brain; abscess in the brain may have its origin in such a process.

The subject of tuberculous invasion of the mastoid does not require extended reference here, as it will be dealt with in the article relating to surgical diseases of the ear.

The flat bones of the skull are occasionally, though rarely, the seat of tuberculous disease, and a number of cases are now on record. The bones most frequently affected are those of the cranial vault, the frontal, the parietals, and the occipital. Headache is complained of, and there is local swelling with tenderness on pressure over the affected area. Sooner or later fluctuation is found, as the result of the development of a chronic abscess.

These bones are most commonly involved in young adults, and, as a rule, there is, at the same time, tuberculous disease in other bones in the body. Thus in a case, which was reported by the author, and in which there was perforation of the parietal bone by tuberculous disease, there were six tuberculous lesions in other parts of the skeleton in addition to the one in the skull.

The disease may begin as a periostitis that soon develops into a superficial caries, but it is apparently more common for it to originate in the diploë. Caseation and suppuration result, or small sequestra may be formed. These are usually about the size of a pea or bean. Perforation of the bone commonly occurs as the result of a necrotic process extending through the entire thickness of the bone. The inner table of the bone may be extensively affected.

When an abscess forms it may come to the surface externally, or it may extend beneath the dura mater, separating it from the bone. Such cases have, in their progress, been associated with symptoms indicative of pressure upon the brain. When a perforation exists the pulsation of the brain may be transmitted to the pus of the abscess. If the abscess opens, and mixed infection occurs, then a septic condition will be induced, with continued suppuration. A probe introduced into such a sinus will impinge upon bare bone in a condition of caries, or it may pass through a perforated bone into tuberculous material which has formed on the surface of the dura mater.

There may be a single focus or there may be several foci in one bone, or, again, several bones may be the seat of disease.

The disease with which this condition is apt to be confused is syphilis. The history of the development of the disease may aid us, but it is sometimes impossible to establish a diagnosis with certainty until an abscess forms or operation is undertaken, when the microscopic finding will demonstrate the true nature of the disease.

The treatment to be adopted in these conditions depends upon the stage of the disease at which the individual case comes under observation. If an abscess has formed and is not yet open, one should incise it and evacuate its contents, remove the diseased bone by curette or chisel, or, if necessary, by trephine, and then endeavor to get the wound to heal by primary union. On the other hand, if septic conditions exist, one must establish efficient drainage after removal of sequestra and all tuberculous tissue. It is usually very easy to separate the sequestra, and in that particular the tuberculous sequestrum of the skull differs from the syphilitic sequestrum, as the latter is usually firmly held in position by the condensed bone which surrounds it.

The outlook in these cases is not at all favorable; the disease is usually part of an extensive and serious involvement of bone in different parts of the skeleton. Even should recovery eventually take place these patients do not improve rapidly, but, as a rule, are subject to frequent recurrences; and, in all probability, several operations will be required before the disease is finally eradicated. A noticeable feature of these cases is the somewhat remarkable manner in which, after recovery has taken place, the gaps in the skull fill in with new bone formation.

The bones of the face are more frequently the seat of tuberculous disease than are the flat bones of the vault of the cranium. The superior maxilla near the orbital margin is occasionally the seat of a tuberculous periostitis that results in caries of the bone and the formation of a chronic abscess. Similar trouble has developed in the malar and in the nasal bones. The author has had under observation a lad eight years of age, who, while suffering from tuberculosis of the tarsus, developed caries of the malar bone.

The lower jaw has been the seat of tuberculous disease. It usually manifests itself near the angle, where a chronic swelling and subsequently a tuberculous abscess may develop. At least one case is on record where spontaneous fracture of the jaw occurred at the seat of a tuberculous lesion.

The treatment of these manifestations of tuberculosis in the facial bones consists in operations carried out for the removal of the disease; for this purpose the methods advocated for the removal of similar foci elsewhere and for the treatment of chronic abscess and fistula may be employed. (*Vide p. 677.*)

Tuberculous Disease of the Temporo-Maxillary Joint.—Tuberculous disease

of this articulation is not of common occurrence. Marsh records two cases in which a tuberculous periostitis of the external aspect of the ascending ramus of the jaw made its way into the temporo-maxillary joint. In one of these there had formed a large collection of pus which extended from the angle of the jaw to the zygoma. When this was opened the surface of the jaw was found to be bare, and a probe passed readily into the interior of the joint. The patient was a boy ten years of age; he ultimately recovered, but the movement of the jaw on that side was much impaired.

Marsh is authority for the statement that tuberculous disease of this joint may occur secondarily to middle-ear disease; suppuration finding its way from the tympanum through the fissure of Glaser into the joint.

The use of counter-irritants may be of service in the early stage of the disease. When abscesses form, they should be opened and treated by appropriate methods already described.

Ankylosis very commonly occurs as the result of disease in this articulation, and the surgeon is called upon to operate for its relief. Under such circumstances resection of the joint becomes necessary.

Tuberculous Disease of the Clavicle and the Scapula.—These bones are rarely affected with tuberculous disease. According to Cheyne the clavicle is most frequently affected at the acromial end, and most commonly the disease is an extension from the acromion process of the scapula. Disease of the sternal end and of the sterno-clavicular joint has also been recorded.

The disease may manifest itself as a chronic periostitis or as an osteomyelitis; if the latter is present there develops a condition similar to that described as "spina ventosa" in the foot or hand.

The glenoid cavity and the neck of the scapula may, as will be seen farther on, be involved in a tuberculous arthritis of the shoulder. Apart from this the scapula is rarely affected with tuberculous disease. The acromion process, however, is sometimes the seat of a primary deposit, and, as already stated, this may spread to the clavicle and infect it secondarily.

No special reference to the treatment of these conditions is necessary, as the methods of dealing with caseous deposits elsewhere indicated should be employed here.

Tuberculous Disease of the Shoulder Joint.—Tuberculous disease of the shoulder joint is extremely rare in childhood. This may be illustrated by the fact that in the Hospital for Sick Children, Toronto, where the patients are all under fifteen years of age, not a single instance of this affection of the shoulder was found in the group of three hundred and fifteen cases of tuberculous arthritis admitted to the wards. According to Whitman,* who bases his estimate upon 3,561 cases of tuberculous disease of joints observed at the Hospital for Ruptured and Crippled, New York, the statistics are as follows:

* "Treatise on Orthopedic Surgery," Lea Bros. & Co., Philadelphia.

Vertebrae . . .	1,432 cases (40.2 per cent)	Elbow joint . .	62 cases (1.8 per cent)
Hip joint . . .	1,123 " (31.5 ")	Shoulder joint.	42 " (1.12 ")
Knee joint . . .	600 " (16.6 ")	Wrist joint . .	7 " (0.2 ")
Ankle joint . .	196 " (5.5 ")		3,561

Thus, in the 315 cases mentioned, there should have been at least 3 instances of tuberculous disease of the shoulder if the same proportion had been maintained.

In the adult, however, while it is a comparatively infrequent manifestation of tuberculous disease, it occasionally occurs.

Anatomical Considerations.—A portion only of the large hemispherical head of the humerus lies in contact with the shallow glenoid cavity of the scapula at any one time; the articular surface of the head of the bone is much more extensive than that of the glenoid fossa. The latter, it is true, is deepened by the glenoid ligament, but the joint is neither osseously nor ligamentously strong; it is dependent upon the muscles which surround it and act upon it, for its stability.

At birth, the upper extremity of the humerus is wholly cartilaginous (Fig. 247). Toward the end of the first year of life, a centre of ossification occurs in the head, followed later by a similar formation in the great tuberosity, and later still in the lesser tuberosity. These three centres unite at the sixth year to form what is described as the upper epiphysis of the humerus, which is separated from the shaft of the bone by an epiphyseal disc of cartilage until the twentieth year of life. This epiphyseal disc of cartilage is shown in Fig. 251, which is a section through the upper part of the humerus and the shoulder joint in a child aged nine. At puberty an osseous nucleus appears also in the margin of the cartilaginous glenoid cavity, which unites at about twenty-five years of age.

The articular capsule is extensive and lax and is attached above to the margins of the glenoidal lip and below to the anatomical neck of the humerus. It is strengthened by the attachments of the tendons of the various muscles which are in contact with it, and by the coraco-humeral ligament passing from the base of the coracoid process above to the tuberosities below. The tendon of the long head of the biceps muscle, arising from the supraglenoid tubercle, passes through the articular cavity, beneath the coraco-humeral ligament; the synovial membrane of the joint accompanies this tendon for a considerable distance outside the joint cavity.

Certain bursa bear important relations to the shoulder joint. Thus, the subdeltoid bursa, which, as a rule, does not communicate with the joint, lies between the deltoid muscle and the capsule of the joint. Distention of this bursa may be mistaken for effusion into the joint cavity. The subacromial bursa lies between the upper part of the capsule and the coraco-acromial ligament. A third large bursa is found between the subscapularis muscle and the anterior aspect of the capsule. This usually communicates with the joint cavity.

Movements in all directions are permitted at the shoulder joint. It is the most freely movable articulation in the body.

Pathology.—The manifestations of tuberculous disease in the shoulder joint are similar to those met in other articulations. Here, as elsewhere, the disease may be primarily synovial, or the bone may be the seat of the primary infection. It would appear that the bone is more frequently the seat of the primary trouble than the synovial membrane.

When the disease occurs in the humerus it is located in the cancellous tissue forming what is known as the upper epiphysis of the humerus, as is shown in section in Fig. 251. This is almost entirely within the line of reflection of the synovial membrane, and consequently the disease cannot come to the surface without invading the joint cavity in the manner which has already been described as possible in some other articulations. The disease in the bone may eventually result in extensive atrophy of the head. While the primary disease in bone is usually situated in the humerus, it occasionally, though rarely, occurs in the scapula.



FIG. 251.—Section through the Shoulder Joint of a Child Nine Years of Age, showing the Epiphysis of the Upper Extremity of the Humerus. (Original.)

Michel Gangolpis, in Le Dentu and Delbet's "Traité de Chirurgie Clinique et Opératoire," 1896, refers to tuberculous disease of the shoulder joint in the following terms:

"In the interesting account published by Audrey and Mondan the statement is made that they examined thirty-two specimens of tuberculous disease of the shoulder joint belonging to the collection of M. Ollier, all of these specimens having been removed from adults or adolescents. The conclusions which they draw from this examination are therefore scarcely applicable to tuberculous disease as it affects the shoulder in young children. Tuberculosis of the shoulder, according to these authors, ordinarily (29 out of 32 cases) manifests itself first in adjacent bone tissue. In 23 of these instances the lesions noted in the humerus plainly predominated over those seen in the scapula, and it was therefore fair to assume that the disease had originated in this bone. In one case, however, there could be scarcely any doubt that it had originated in the scapula. In 10 instances there was only a single lesion in the humerus; in 19 there were multiple lesions; and in 4 both the humerus and the scapula were coincidentally involved. As has been noted in other regions of the body the epiphysis was the commonest seat of the disease (22 times); in 5 cases the tuberculous lesions involved both the epiphysis and the diaphysis. It is only in exceptional cases (5 out of 32) that the epiphysis escapes, the disease then being located in the adjacent part of the bone; and still more rarely (2 instances) do we find it restricted to the diaphysis."

Chronic abscesses may form, and these usually make their way to the surface about the insertion of the deltoid, but where they burrow extensively they may come into the axilla or infiltrate the tissues over the chest.

The condition of *caries sicca*, described on page 579, more commonly occurs in the shoulder than in any other joint. In this manifestation of tuberculous disease there is no swelling, but a progressive atrophy of the structures in and about the joint. Dense fibrous tissue forms, the articular cartilage is destroyed, and firm ankylosis eventually occurs. Abscess rarely forms in this condition.

Symptoms.—The symptoms of disease are not as marked in the shoulder joint as in the joints of the lower extremity, mainly for two reasons. First, the joints of the lower limb are constantly brought into action in weight-bearing, and this aggravates the symptoms there, as is not the case in the arm; secondly, the disability produced by stiffness at the joint is masked by the mobility of the scapula. The onset is insidious and the disease runs a very chronic course, as a rule. Pain, often of a neuralgic character, is complained of, and this is most in evidence at night. Local tenderness on pressure usually exists, particularly over the anterior aspect of the joint.

Limitation of movement will be appreciated if the scapula is first fixed and passive movement then carried out. While a certain amount of movement is possible without pain, yet one finds that extreme movement in any direction is resisted by muscular spasm. The movements of rotation are most appreciably affected, the probable explanation being that the scapula cannot contribute by its mobility to these movements as it can, for example, in abduction and adduction.

In the early stages there may be appreciable swelling about the joint, with obliteration of the normal depressions which exist on the sound side, and effacement of the bony prominences to a greater or less extent. The characteristic feature of muscle atrophy manifests itself here, as elsewhere, and the circumferential measurements are usually diminished. Atrophy of the deltoid produces a flattening of the shoulder and causes the margin of the acromion to become unduly prominent. Muscle atrophy will also be present in the arm and forearm.

Abscess formation is common and may come to the surface in front of or behind the deltoid near its insertion. In advanced disease and where mixed infection has occurred, numerous sinuses may burrow widely in and about the shoulder.

When the disease is present in children, the epiphyseal cartilage is usually destroyed, and as a result the growth of the limb in length is interfered with, and it becomes shorter than its fellow. This shortening may be increased by the progressive destruction of the head of the bone.

Diagnosis.—The diagnosis may present considerable difficulty. The effects

of trauma, which have brought about adhesions and limitation of movement, may produce symptoms suggesting tuberculous trouble. The history of the case and the gradual development of the disability in tuberculosis will assist one to form an opinion. Arthritis deformans in the early stage simulates tuberculous arthritis closely. Here, grating on movement, due to erosion of the cartilage with comparatively slight pain on passive movement, helps one in many instances to distinguish the condition from tuberculosis. The occurrence of a new growth in the shoulder may, in the early stages of its development, produce symptoms like those caused by the presence of a deposit of tubercle. The course of the disease soon clears up the diagnosis; the tumor enlarges without any implication of the joint cavity, and careful examination may enable one to ascertain the true condition of affairs.

If trouble in the shoulder develops in a tuberculous patient, one is assisted materially in forming an opinion of its true nature, the presumption being in favor of tuberculous disease.

Tuberculous disease of the shoulder usually results in some impairment of function. In cases subjected to the expectant method of treatment, we have, as a rule, some degree of permanent stiffness after the disease is eradicated. It is worthy of note that the disease here is more frequently complicated with pulmonary tuberculosis than is the same disease when it involves one of the other joints, and this fact is utilized as an argument by some authorities for early operation in order to establish speedy convalescence, and thus diminish the chances of the supervention of lung trouble.

The results obtained by excision in the adult are satisfactory; a useful movable joint is secured by such means.

Treatment.—Conservative measures may be adopted in the early stages of the disease, and the general principles for providing fixation and rest which have been advised for other joints should be employed. The limb must be secured in good position, as the possibility of ankylosis occurring must be borne in mind, and the attitude in fixation must be that which will prove most serviceable should the joint become stiff. A plaster-of-Paris spica, like that shown in Fig. 252, may be employed. The limb should be slightly abducted and fixed in a position midway between extreme inward and extreme outward rotation. If the case progresses favorably, the fixation apparatus may be abandoned after three or four months, and the arm carried in a sling for a further period of similar duration.

If, however, the disease is making progress, then there should be no delay in proceeding to operative measures. This, in the adult, should take the form of excision of the head of the bone along with all diseased tissue; while in the child a less formal procedure may suffice, depending upon the extent of the disease, an attempt being made to save the epiphyseal disc of cartilage if the amount of disease present should warrant it.

The best method of exposing the shoulder joint for the purpose of eradicating tuberculous disease, is that by an anterior incision. This begins immediately external to the tip of the coracoid process and passes for four inches downward and outward, parallel to the anterior border of the deltoid muscle. The incision is carried through the skin and fascia, while the arm is slightly abducted and rotated outward. The capsule of the joint is exposed in the upper part of the wound, and the tendon of the biceps is defined below. The tendon is



FIG. 252. Plaster Spica Applied to the Shoulder in Tuberculous Disease of the Shoulder Joint.
(Original.)

freed from the groove in which it lies, and the deltoid is raised from the structures subjacent to that muscle and drawn forcibly outward. The front of the capsule is cleared and cut away with scissors. The arm is now allowed to hang vertically over the side of the operating table and the head of the bone is pushed upward through the opened capsule the muscles attached to the tuberosities being divided as far as may be necessary to effect our purpose. The head is then sawn through, as much of the tuberosities being left as the extent of the disease will warrant. The cavity of the joint is now carefully inspected and all diseased tissue removed. If the glenoid cavity shows evidence of disease, this must also be removed. The wound is then closed in the usual way

and the limb secured in a plaster spica encircling the chest and passing down the limb to the wrist. Cheyne advises that a pad should be placed in front of the joint to prevent the forward displacement of the upper end of the bone, an event which sometimes occurs. After four or five weeks the plaster is removed and passive movement begun. If only a small portion of the bone has been sacrificed, passive movement may be begun as early as the beginning of the third week.

A similar incision and exposure of the joint may be used for the purpose of removing limited foci of disease in the child.

In cases in which bony ankylosis has occurred, a similar operation may be performed and the bone divided by means of a chisel. The cutting should extend through the humerus at the desired level, and by similar means a separation of the articular portion of the glenoid process of the scapula should be effected.

Chronic abscesses which are apt to occur in connection with tuberculous disease in this part of the body, are treated along the lines advocated for such conditions elsewhere. (*Vide* p. 677.) Should mixed infection occur, then the main object to be had in view is to secure efficient drainage.

Amputation might be called for in advanced and neglected cases where the septic processes have produced extensive destruction of the structures in and about the joint, and where the patient's life is endangered by conditions which cannot be relieved by less drastic measures.

Tuberculous Disease of the Elbow Joint.—Tuberculous disease is more common in the elbow than it is in the shoulder. It is, however, a rare affection in the child. Cheyne's statistics showed that 7.9 per cent of all cases of tuberculous arthritis were affections of this joint, but of these the disease manifested itself mainly in young adults, in most of the cases (66 per cent) the disease beginning between the ages of twelve and twenty. One-third of the cases began before ten years of age. Whitman's statistics of 3,561 cases of tuberculous arthritis in the Hospital for the Ruptured and Crippled, of New York, showed 62 (*i.e.*, 1.8 per cent) of elbow-joint disease. Of 315 cases of tuberculous arthritis admitted to the wards of the Hospital for Sick Children, Toronto (*i.e.*, children under fifteen years of age), not a single case of tuberculosis of the elbow was reported. It would thus appear that statistics vary regarding the occurrence of the disease but it is obvious that it is comparatively infrequent at any age.

Anatomical Considerations.—This is a typical compound joint,—the trochlea of the humerus articulating with the greater sigmoid fossa of the ulna, the head of the radius articulating with the capitellum of the humerus, while the circumferential articular surface of the radial head articulates with the lesser sigmoid notch.

The capsular ligament is extensive and lax, particularly in front and behind

Its attachment to the humerus is such that it includes within the capsule the three fossæ—the olecranal, the coronoid, and the radial. Laterally, the capsular ligament is re-enforced by the lateral ligaments. The ulnar attachment of the capsule is to the olecranon just below its tip, also on the margins of the great sigmoid notch, and anteriorly to the tip of the coronoid. The radial attachment is such that the entire head and a portion of the neck of the radius are within the capsule, and the radius is held in contact with the ulna by the strong orbicular ligament which is attached to the margins of the lesser sigmoid notch.

In the child at birth the whole of the portion of the humerus within the capsule is cartilaginous (see Fig. 247), as is also the intra-articular portion of the radius. The upper part of the olecranon process is also still cartilaginous. The lower epiphysis of the humerus is formed by the coalescence of three ossific centres which appear in the following order: The capitellum at the third year, the inner part of the trochlea at the twelfth year, and the external condyle also about the twelfth year. The centre for the internal condyle appears at the fifth year and remains as a separate epiphysis. The lower epiphysis of the humerus unites with the shaft at the seventeenth year, and that for the internal condyle at the nineteenth year. The upper ulnar epiphysis is a centre which appears at the upper part of the olecranon process, the greater part of that process having been ossified from extension from the shaft. This appears at the tenth year and unites at the sixteenth. The head of the radius forms an epiphysis. The centre appears at the sixth year and unites with the shaft at the age of twenty. It thus appears that in dealing with the elbow we have cartilage persisting throughout early childhood to an extensive degree. Where such conditions exist, the joint is not prone to the inroads of tuberculous disease. The existence of these various centres of ossification must be borne in mind while interpreting an x-ray picture in children.

The strength of the articulation is due, first, to the security afforded by the orbicular ligament which attaches the radius to the ulna; then to the grip which the ulna has upon the lower end of the humerus, because of the conformation of the bones; and, lastly, to the aid which the strong lateral ligaments afford. These facts should be borne in mind, so that the stability of the joint may be preserved in any conservative operation for the eradication of disease.

Of the bursæ about the joint, the following may be noted: the subcutaneous olecranal bursa, situated between the skin and the olecranon, and the internal and external epicondylar bursæ which exist, one over each condyle; lastly, the bicipito-radial bursa between the tendon of the biceps and the neck of the radius. Affections of any of these bursæ—more particularly the subcutaneous olecranal bursa—might be confused with tuberculous disease in the joint.

The movements at the articulation in the case of the humero-ulnar joint

are those of flexion and extension. Similar movements occur at the humero-radial joint, but here rotation also takes place. The movements of rotation (pronation and supination) are carried out both at the humero-radial and at the radio-ulnar joint.

It must be remembered that the axis of the arm is not in line, under normal conditions, with the axis of the forearm. Thus if an individual stands erect, with the upper extremity held vertically at the side, and the palm of the hand looking forward, the axis of the arm lies vertically, but that of the forearm passes downward and outward, forming the so-called "carrying-angle" with the axis of the arm. This should be preserved in operations on the elbow.

Pathology.—The disease begins more frequently in bone than in synovial membrane. Its most frequent site is the olecranon process of the ulna. Next in order of frequency is the humerus, and here most often it is in the external condyle. Much more rarely the disease has been primary in the head of the radius. The trouble may spread to the synovial membrane and infect it secondarily. In advanced disease the ligaments become involved and possibly the bursæ about the joint also.

Symptomatology.—The disease here, as elsewhere, runs a chronic course. Pain at first is slight, and the progressive development of stiffness is often the first symptom of trouble. When pain does appear, it is, as a rule, localized at the elbow and is increased by sudden movement at the joint. Localized tenderness on pressure should be carefully sought for. The joint is superficial and accessible for such examination, and it is sometimes possible to locate a focus of disease in the olecranon before the joint cavity has been implicated.

Swelling is small in amount at the outset, and, when it does supervene, is first noticed on either side of the olecranon and the tendon of the triceps muscle. Later, when the swelling becomes more general, the joint assumes the characteristic fusiform shape, with obliteration of the normal depressions about the joint and effacement of the bony prominences. When the disease is of long duration the swelling may become very great.

The limitation of movement in the early stage is found at the extremes of the arc of motion. Thus complete flexion or extension is resisted by muscular contraction, as is also the movement of pronation or supination in a similar manner. Eventually the joint is fixed in a position midway between extreme pronation and supination. This represents the characteristic faulty attitude which is assumed in advanced disease.

One may be able to detect a slight increase in heat on the affected side. Atrophy of muscle is developed and will be detected by the measurements of the arm and forearm, as compared with those of the sound side. Abscess formation may occur and most frequently appears on the posterior and outer side of the joint.

The x-ray may be of service in establishing a diagnosis. Fig. 253 is an x-ray

photograph of the right elbow of a lad thirteen years of age who was suffering from tuberculous disease in that joint. The head of the radius is shown to be destroyed. The patient had had symptoms of trouble for four months. An operation was performed and the head of the radius was found to be tuberculous, while a large periarticular abscess had formed which communicated by a sinus with the seat of disease.

Prognosis.—Unless one succeeds in eradicating the disease at a very early stage, the chances of securing a joint free from some degree of permanent stiffness are not good.

Treatment.—Expectant treatment may be carried out with advantage in many instances. The joint is fixed at a right angle by a plaster-of-Paris splint

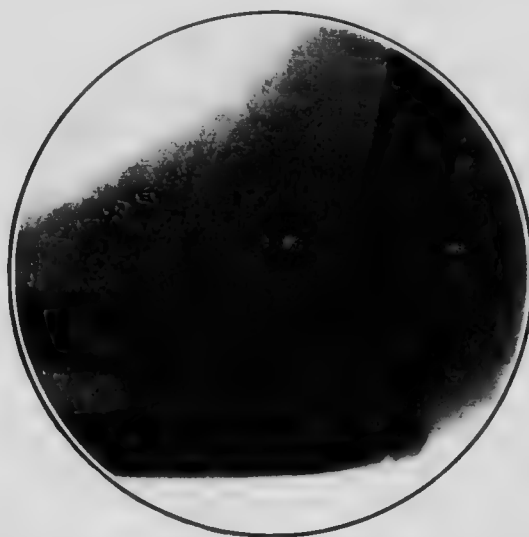


FIG. 253.—Skiagraph of Tuberculous Disease of the Right Elbow Joint in a Patient Aged Thirteen Years. The disease had existed for four months. The head of the radius is almost entirely destroyed, while the ulna and humerus are normal. (The x-ray picture was taken by Dr. S. Cummings, of Toronto, from a case that occurred in his practice.)

in a position midway between pronation and supination. The splint should extend from the axillary fold to the wrist. The length of time necessary for the maintenance of fixation must vary in individual cases. In early cases fixation for six months may be sufficient, and subsequently the arm is carried in a sling for some months longer, depending upon the progress of the case. In many instances it is found necessary to retain the fixation apparatus for a year. A certain degree of permanent stiffness results, excepting, perhaps, in some cases of pure synovial disease where the trouble has been arrested by efficient treatment at an early stage. After the retention splint has been removed, passive movement and massage may be carried out with a view of grad-

ually increasing the degree of movement and of restoring the normal function of the joint.

Bier's treatment by passive hyperæmia may prove of service, and is advocated in these cases; for a description of the technique see page 590.

Occasionally the case comes under observation with fixation of the limb in a faulty attitude. This is more frequently that of a joint stiff in the attitude of more or less extension. This may be corrected by gradually bringing the joint into the flexed position by manipulation and the application of a plaster-of-Paris splint. The correction of the faulty attitude may be accomplished after a series of such manipulations, the application of each plaster splint securing the limb in an improved position, until eventually the deformity is corrected. It may be necessary to give an anæsthetic in some cases to correct the faulty position.

Should the disease make progress under expectant treatment, then operative interference is indicated. In fact, in the elbow, operative treatment is indicated earlier perhaps than in any other of the large joints when tuberculous disease is present. This is the case because in the elbow tuberculous disease of a progressive character produces marked disability, even when a favorable course is run after expectant treatment, and operative treatment is eminently successful in securing a good functional result.

In children, the operation of arthrectomy, with removal of the diseased tissues, should be the operation of election; while in the adult, excision is the better operation.

The method of opening the elbow joint for arthrectomy or excision suggested by Kocher, of Berne, is perhaps the most generally serviceable. The description is taken from Stile's translation of Kocher's "Operative Surgery." The elbow is flexed to an angle of about one hundred and fifty degrees. An incision is begun over the external supracondylar ridge, two inches above the line of the joint. This is carried vertically downward to the head of the radius, and from thence inward, along the outer border of the anconeus muscle to the outer border of the ulna, which is reached three inches below the tip of the olecranon; finally, the incision terminates by curving over the inner surface of the ulna. The first part of the incision extends downward to the outer border and the external condyle of the humerus, between the supinator longus and the radial extensors anteriorly, and the edge of the triceps posteriorly; below the external condyle it passes down to the bone between the extensor carpi ulnaris and the outer border of the anconeus, and divides the strong capsule over the head of the radius together with the orbicular ligament at its attachment to the ulna. The lower end of the incision divides the lower fibres of the anconeus transversely at their attachment to the posterior border of the ulna, because the muscle extends for a considerable distance down the forearm. The incision, therefore, falls accurately along the interval between the muscles sup-

plied by the musculo-spiral nerve and those supplied by the posterior interosseous, thus avoiding the possibility of subsequent muscular atrophy. The bone having been exposed and the capsule divided, the outer head of the triceps, together with the periosteum and the upper attachment of the capsule, is detached subperiosteally from the humerus, the anconeus from the posterior surface of the ulna, the insertion of the triceps from the tip of the olecranon, and the triceps-anconeus flap is (the joint being extended) displaced over the olecranon to its inner side. The external lateral ligament, with the attachments of the extensor tendons and the capsule attached to the external condyle, are separated subcortically from below by means of a chisel and drawn



FIG. 254.—Skiagraph showing a Tuberculous Abscess in the Lower End of the Right Radius. The patient was fifteen years of age and had complained of disability in the right wrist for three months. The diagnosis was confirmed at the time of operation. (The x-ray picture was taken by Dr. S. Cummings, of Toronto, from a case that occurred in his practice.)

forward. The joint has now become so movable that the forearm can be completely dislocated inward. The whole extensor apparatus, as regards both muscles and nerves, is preserved in its continuity, and the internal lateral ligament is still intact. If complete resection is to be performed, after the joint has been dislocated as above described, the internal lateral ligament is separated subperiosteally along with the muscles from the inner border of the ulna and the internal condyle of the humerus, and the ends of the bones are removed. In separating the lateral ligaments, it is better to remove a shell of bone along with them, so as to preserve their attachment to the periosteum.

After the completion of such an operation the limb is secured in plaster. If the operation consists in an arthrectomy, such as is occasionally advisable in children, the limb is kept at rest in the plaster for three or four weeks, and

subsequently retained in a sling for two or three weeks longer. Passive movement may be carried out after the plaster is removed, and this is specially to be insisted upon as regards pronation and supination.

After excision, the plaster should be removed at the end of two weeks, and gentle passive motion begun. We desire to get a movable joint, and, after excision, it is quite remarkable to what extent the normal movements may be restored. Fixation apparatus may be abandoned after four weeks, as a rule, and, by degrees, free use of the limb is secured.

Where a large amount of bone has to be sacrificed, there is the danger of a flail-like joint. Under such circumstances it is wise to maintain the fixation apparatus for a considerably longer period.

Abscesses forming in connection with tuberculous disease of the elbow must be treated along lines precisely similar to those recommended in the other joints. (*Vide* p. 677.) Where mixed infection has occurred, free drainage is the important thing to obtain, and efficient measures must be adopted to secure it.

Amputation is justifiable only where extensive and destructive septic processes have made it obvious that it is impossible to save a useful limb, and where the patient's life may be endangered.

Tuberculous Disease of the Wrist Joint.—Tuberculous disease of the wrist joint is a rare affection in children, and is not very often met with at any age. Cheyne's statistics gave disease at the wrist as constituting five per cent of the total cases of tuberculous bone and joint disease. Of 315 cases of tuberculous arthritis admitted to the wards of the Hospital for Sick Children, Toronto, there were 4 (*i.e.*, 1.3 per cent) cases of wrist-joint affection.

Anatomical Considerations.—The radio-carpal joint is formed of the following elements: the inferior articular surface of the radius and the inferior aspect of the triangular fibro-cartilage upon the proximal side of the joint, and the scaphoid, semilunar, and cuneiform bones on the distal side. The continuity of the carpal articular surface is in part maintained by interosseous ligaments which exist along the level of the articular cartilage between the carpal bones concerned. The radio-ulnar joint exists, at the wrist, between the capitellum of the ulna and the sigmoid notch of the lower end of the radius; it also extends between the capitellum of the ulna and the upper surface of the triangular fibro-cartilage. This joint is entirely separate from the radio-carpal joint and is associated in its function with the upper radio-ulnar joint in the movements of pronation and supination. The triangular fibro-cartilage is attached to the ulnar margin of the lower articular surface of the radius and to the styloid process of the ulna.

Between the two rows of carpal bones there exists the intercarpal articulation; this constitutes a somewhat extensive and complicated synovial cavity between the carpal bones, forming among these a common joint cavity with the exception of the joint between the pisiform and the cuneiform, which is separate.

This intercarpal joint may in some cases be still more extensive when, as sometimes occurs, the interosseous ligaments, referred to above, are absent; when this occurs the intercarpal joint communicates with the radio-carpal. In similar fashion the intercarpal joint may communicate with the carpo-metacarpal joint. The latter communication is in fact more common than the former. There is a common cavity between the distal row of carpals and the metacarpals, with the exception of the joint between the trapezium and the metacarpal bone of the thumb, which is separate and distinct.

The carpal bones are held together by a series of palmar, dorsal, and interosseous ligaments.

It must be remembered that the lower end of the ulna is cartilaginous until the sixth year, when the centre of ossification for the epiphysis appears; this unites with the shaft at the twenty-third year. Similarly, the epiphysis for the lower end of the radius appears at the second year, and unites with the shaft at the twenty-fifth year.

The carpus is wholly cartilaginous at birth (see Fig. 247). The first carpal to show an ossific centre is the os magnum, at the end of the first year; shortly after, the unciform centre becomes evident; next come the cuneiform at the third year, and the semilunar and the trapezium about the sixth year; then the scaphoid and trapezoid at the sixth or seventh year, and lastly the pisiform at the twelfth year. These facts should be borne in mind in interpreting x-ray pictures of the wrist and carpus in a child. Similarly, the development of the epiphyses of the metacarpals and phalanges should be remembered.

The synovial sheaths of the flexor and extensor tendons not infrequently take part in the tuberculous processes about the wrist, and their intimate relations to the bones in this locality demand attention, particularly when operative treatment is undertaken.

Pathology.—Tuberculous disease at the wrist may occur primarily in bone or in synovial membrane; the latter is in all probability the more common. When it commences in bone, the deposit is generally in the lower end of the radius or at the base of the metacarpal bones, generally the second. (Cheyne). Abscess formation is very common in connection with disease here; and tuberculous disease elsewhere in the body, more particularly pulmonary tuberculosis, is not uncommonly present. A tuberculous teno-synovitis beginning in any of the tendon sheaths is often present; it may, in fact, be a primary condition from which invasion of the joints may occur secondarily.

Symptomatology.—Pain, stiffness, and swelling gradually develop. At the outset the degree of limitation of movement is slight and the pain moderate in amount. As the disease progresses, the swelling increases, so that the bony prominences about the wrist are no longer in evidence and the wrist takes on the characteristic fusiform shape of tuberculous arthritis. The swelling is most marked on the dorsal aspect and about the extensor tendons. There is

marked disability, so that the patient is unable to move the wrist without support.

In the later stages the pain becomes severe, particularly when the cartilages are eroded and the synovial membrane, both of the wrist and of the tendon sheaths, becomes infiltrated. Eventually adhesions form in the tendon sheaths and the joints become immobile, usually in an attitude of slight flexion with a tendency to dislocation forward at the wrist joint. The lateral ligaments are not infrequently infiltrated and softened at a fairly early stage, permitting a slight degree of lateral movement at the wrist. Atrophy of the muscles of the arm and forearm occurs as in tuberculous arthritis elsewhere.

Abscess formation is very common, and the abscess first forms on the dorsum, as a rule. Mixed infection is apt to occur, and the part may become riddled with septic sinuses.

The patient's general health suffers markedly in advanced cases. The pain disturbs his rest at night, and his general nutrition is badly maintained.

Diagnosis.—The diagnosis of disease at the wrist is not difficult. The progressive character of the symptoms described is characteristic. The x-ray may be of value in determining the extent of the disease. Plate XXVII, Fig. 1, shows disease in the right wrist in a child two years of age. There had been symptoms in this case for three months, and the x-ray shows tuberculous disease of the os magnum and the unciform bones, along with the bases of the second and third metacarpal bones.

Treatment.—Expectant treatment should be carried out here with the greatest care, as operative methods of dealing with the disease do not afford a very good prospect of a satisfactory functional result.

The simplest method of fixing the wrist is in a plaster splint applied from the heads of the metacarpal bones to the elbow. The limb should be placed in the most favorable attitude for ankylosis should fixation of the joints occur. The metacarpus should be dorsi-flexed to a slight degree at the wrist. The thumb should be allowed to drop forward, the ball of the thumb rolled inward toward the palm, and the fingers slightly flexed. The fingers should be moved freely every day. This can be most effectively carried out by the patient, who should produce the motion by bringing the muscles into voluntary action, but his efforts must be supplemented by passive movement.

Should flexion deformity exist it may be overcome by degrees, plaster of Paris being used for fixation, and at each application the position should be gradually improved.

The Bier treatment by passive hyperemia may be carried out with advantage and should be combined with fixation. The technique of the Bier treatment is described at page 590.

Should the expectant treatment fail to effect satisfactory results, and should the disease continue to progress, some form of operative interference is indicated.

Excision of the wrist may be carried out by the method introduced by Lord Lister through two incisions, one upon the dorsal aspect toward the radial side, and the other on the anterior aspect along the ulnar border of the wrist. The operation of excision recommended by Kocher, of Berne, is, however, perhaps the most satisfactory and is accomplished through a single dorsal incision described as a "dorso-ulnar incision." The incision is three and one-half inches long, begins over the middle of the fifth metacarpal bone, and is continued upward over the middle of the wrist joint, and from thence over the middle of the back of the forearm. After the operation has been completed, the limb is secured upon a suitable splint and fixed in the attitude already described in the section relating to expectant treatment.

Abscesses developing in connection with disease in the wrist must be treated along lines elsewhere advocated for other joints (see page 677). When mixed infection occurs, free drainage must be secured by whatever operative means is necessary for accomplishing that purpose.

Amputation is necessary in certain cases. Where septic processes have brought about extensive destruction of the structures about the wrist, and where there is no longer any possibility of saving a useful wrist and hand, one must of course amputate. In individuals in enfeebled health, with perhaps tuberculous disease elsewhere, if operation becomes necessary, it is best to amputate.

Tuberculous Disease of the Metacarpals and Phalanges.—The metacarpals or the phalanges may be the seat of tuberculous disease. The most common manifestation is that in which the shaft of the bone becomes the seat of a deposit centrally. The osseous tissue is gradually destroyed, and while this is in progress new bone is formed under the periosteum. The bone becomes fusiform in shape and appears as if ballooned out in the centre of the shaft. The term "spina ventosa" has been given to this condition. Several phalanges and metacarpals may be affected in the same hand.

Spina ventosa is common in childhood, and is much more common than it is in adult life.

The appearance presented in this condition is very characteristic. The shape of the bone and the history of the gradual development of the condition render the diagnosis easy. The only condition with which it might be confused is that of tertiary syphilis; the history of the patient will throw light upon the question in a doubtful case.

Treatment.—Rest by suitable splinting, with perhaps compression by means of adhesive plaster, may effect a cure. These cases will often do well after an operation carried out with the view of removing the focus of disease from the bone. The bone should be opened up and thoroughly curetted with a sharp spoon. The wound may then be closed and the part splinted, or it may be packed with sterile gauze and allowed to granulate. Where one cannot save a useful finger it is best to amputate the digit.

Tuberculosis of the Metacarpo-Phalangeal and of the Interphalangeal Joints.—Tuberculous disease in these small joints occurs occasionally. The local manifestations here are similar to those in the larger articulations, viz., a slow chronic enlargement of the joint with a slight amount of pain and stiffness. A joint is sometimes invaded from a bone which is the seat of a spina ventosa, but occasionally the disease is primary in the joint.

Treatment by rest and splinting may be effectively carried out, but operation is usually necessary. In the interphalangeal joint affections, amputation is necessary, as a rule, but, when the metacarpo-phalangeal articulations are involved, excision should be done where there is a good prospect of eradicating the disease by such a method. It is especially desirable to choose excision rather than amputation in the treatment of the metacarpo-phalangeal joint of the thumb.

Tuberculous Disease of the Sternum and Ribs.—The disease here may be superficial, developing as a periostitis and resulting in a superficial caries, or it may begin centrally as an osteomyelitis.

In the case of the sternum, when the surface of the bone is affected on its posterior aspect the disease may spread extensively and its nature may not be determined until an abscess has formed and has made its appearance between the ribs. Such an abscess may be mistaken for a localized empyema.

In the interior of the bone caries may give rise to cavities containing soft necrotic material, or necrosis of bone may lead to the separation of small sequestra.

Abscess very commonly develops, and this makes its way to the surface. If it is not properly cared for, infection by pyogenic organisms is apt to occur, and the septic processes induced result in further destruction of tissue and the persistence of discharging septic sinuses.

The ribs are not infrequently the seat of a tuberculous process, the occurrence of the disease in this locality being practically confined to adults. It may develop as a secondary process in individuals suffering from tuberculous pleurisy, or by extension of the disease from the spine. The middle series of ribs (from the fourth to the eighth) are most frequently affected. The most common manifestation is, in all probability, originally a periostitis leading to superficial caries, but not infrequently the trouble begins as a central lesion producing a chronic form of osteomyelitis.

The rib may be so softened by caries that fracture may occur, or portions of bone may be separated as sequestra. The disease not infrequently presents itself in numerous foci in the same rib, or a series of ribs may become affected. Thus the author had recently under his care a patient in whom five ribs and the sternum were the seat of separate foci of disease.

The symptoms are indefinite at the beginning; a chronic localized swelling, with some tenderness on pressure, is usually the first symptom to attract the

attention of the patient. In the case of the ribs, there may be pain on coughing or on drawing a deep breath. The swelling, which at first is firm and tender, may subsequently soften and fluctuate as abscess formation occurs. Such an abscess may open into the pleural cavity or upon the skin surface. Occasionally it burrows among the muscles and comes to the surface at some distance from the seat of the osseous disease. An abscess pointing in the loin may develop from disease at the posterior end of the rib, or the abscess may spread into the sheath of the psoas and form a typical psoas abscess. (Cheyne)

Treatment.—Caseous foci must be opened and curetted; diseased portions of the sternum may be removed. In the case of the rib, when it is possible to diagnose a localized focus of disease, a portion of the bone should be removed, all tuberculous tissue dissected out, and thus the disease may be eradicated and a speedy cure effected. This may be done successfully even where abscess is present; the wound is then closed without drainage, and primary union may be expected.

Should mixed infection occur, then it is necessary to curette thoroughly and establish efficient drainage, the wound being allowed to granulate slowly.

The case frequently runs a chronic course, particularly where there are multiple foci of disease, but there is very little tendency to the development of general tuberculosis, as a rule, and good results may finally be obtained even where extensive disease has existed.

Tuberculous Disease of the Hip Bone, Apart from the Joints.—It must be remembered that a tuberculous deposit may occur in the hip bone quite apart from the articulations which it forms. Here again the region of the epiphysis is apparently more prone to develop the disease than is any other part of the bone. The crest of the ilium, for example, is an epiphysis which appears at puberty and unites at twenty-five years of age. Here tuberculous disease sometimes occurs and may result in an extensive involvement of the crest.

These isolated deposits of tubercle are rendered evident at an early age of their development by persistent tenderness on pressure and some disability while the patient is moving about, pain being produced when the muscles attached to the affected portion of the pelvis are brought into action. The x-ray has been found useful in demonstrating the existence of such tuberculous deposits. The development of an abscess is often the first indication of the true nature of the trouble. This must be treated in the manner elsewhere fully described (p. 677), and portions of the diseased bone which may be laid bare when the abscess is opened should be removed.

Tuberculous Disease of the Sacro-iliac Joint. Tuberculous involvement of this joint is by no means as common as is similar disease in the hip or knee, but it occasionally occurs and is always to be looked upon as a serious

condition. The disease may begin in either the sacrum or the ilium, and involve the articulation secondarily.

The weight of the trunk is transmitted from the spine to the pelvis through the sacro-iliac joints. The articular surfaces of each of the bones entering into the joint are covered by hyaline cartilage, that on the sacrum being thicker, but these surfaces are uneven and are not adapted for free movement upon one another. As a fact very little movement is possible at the sacro-iliac joint under normal conditions; Goldthwait and Osgood have demonstrated, however, that a limited amount of mobility is possible; the stability of the joint is secured both by the irregularity of the articular surfaces just referred to and by the strong ligaments which bind the two bones firmly together. The synovial cavity of the joint is very imperfect and rudimentary; in some cases the two surfaces are connected together throughout a part of their extent by fine transverse fibres. Fig. 247 shows a section through the joint in a child one year of age. It will be observed that a layer of cartilage of considerable thickness covers the sacral portion of the joint surface. In this cartilage at the time of puberty an epiphysis appears, and an irregular plate of bone here develops which unites with the lateral mass of the sacrum about the twenty-fifth year. The bones are held together by anterior and posterior sacro-iliac ligaments, and the articulation receives additional support from the great and small sacro-sciatic ligaments. The posterior ligament is very strong and in fact contributes the main ligamentous strength of the joint; it consists of a large number of strong irregular bundles which extend from the rough area above the auricular surface of the ilium to the depressions on the back of the lateral mass of the sacrum. The anterior sacro-iliac ligament consists of thin fibres passing irregularly from the ilium to the sacrum on the anterior aspect of the joint.

The etiological factors at work here are similar to those in the case of disease in other joints (*vide* page 564). It is characteristically a disease of early adult life; it is rare in childhood and in old age, and is most common between the ages of twenty and thirty-five years. If we inquire into the cause of the comparatively late appearance of tuberculous disease of this joint, we may observe that the sacral epiphysis, already referred to, appears late, namely, at the time of puberty, and unites with the bone at twenty-five. It may be that the late appearance of this epiphysis has something to do with the tendency for late manifestation of the disease, as tuberculous affections obviously bear some definite relationship to the developing epiphyses—the neighborhood of which the disease much more frequently occurs than in other portions of the skeleton. In this connection, too, it is significant that the manner in which the disease most commonly starts is in a deposit in the sacrum. Injury is doubtless a common etiological factor.

The joint may be involved primarily or it may be affected secondarily to disease of the lower lumbar vertebrae. When the affection develops secondarily to lumbar disease it most commonly commences as a periostitis. (Cheyne.)

The sacrum or the ilium may be the seat of the primary disease, the deposit occurring in the cancellous tissue of either bone, but the sacrum is more commonly the starting-point. The ligaments may subsequently become involved, and abscess development is not uncommon. When abscess forms, it more commonly spreads downward into the pelvis, as might be anticipated, because the weaker ligament is situated anteriorly.

Symptoms.—The disease is often very insidious in the early stages. A sense of fatigue and weakness in the lower part of the back and in the neighborhood of the joint, with a feeling of insecurity, is complained of. The pain frequently radiates over the buttock and along the course of the sciatic nerve, possibly as far as the knee joint. It is increased by exertion and is most noticeable after walking about during the day, while in the morning some degree of stiffness is present. The pain is increased by sudden exertion, especially on turning the body, or on suddenly rising from the sitting posture. Pain may be elicited, while the patient is being examined in the recumbent posture, by grasping the iliac bones on either side and rocking the pelvis from side to side. If he lies upon the back, and if the foot of the affected side be elevated with the knee extended, the range of motion will be found to be markedly limited and the procedure will often produce pain in the region of the sacro-iliac joint. The explanation is found in the fact that the traction on the hamstrings produces motion at the sacro-iliac joint and consequently pain. There may be tenderness too on direct manipulation over the joint, or by compressing the joint laterally while grasping the two iliac crests. The anterior aspect of the joint in its lower part may be reached by rectal examination, or by way of the vagina, and pain may be elicited by palpation in this region. The existence of a limp while walking is another symptom which is combined with faulty attitude. The patient tends to throw the weight of the body on the sound limb, with the result that the pelvis is lowered and rotated forward on the affected side, and the limb on that side seems elongated; this in turn induces a certain degree of lateral curvature of the spine. Muscular atrophy is present here as in other cases of tuberculous arthritis, and may be noticeable in the buttock, in the thigh, and in the leg. Abscess is a common complication, and in fact the disease may in some instances progress to the formation of an abscess without having previously caused much pain or discomfort; and so the existence of a fluctuating tumor may be one of the first symptoms to indicate the gravity of the condition present. The abscess may appear posteriorly and from the outset exist as an extrapelvic formation of pus, but more commonly it develops anteriorly and is intrapelvic. The pus may pass into the iliac fossa and invade the psoas fascia and eventually find its way into the thigh, or it may work its way through the sciatic or obturator foramen, occasionally passing into the perineum. Sometimes it has ruptured into the rectum. Intrapelvic abscesses may be detected by rectal or vaginal examination. If the abscess ruptures spontaneously,

mixed infection is sure to occur, and then a most serious condition is at once instituted. Persistent sinuses develop, and the patient suffers the usual sequence of events attendant upon long-continued suppuration and discharge, resulting eventually in most instances in a fatal issue.

Diagnosis.—The diagnosis of sacro-iliac disease is occasionally difficult. The condition may be confounded with sciatica, which, however, is more likely to occur later in life than sacro-iliac disease. The recumbent posture will afford relief where the joint is involved, and is not likely to do so in sciatica; then, too, pain produced by rotation of the pelvis is not pronounced in sciatica. Disease of the hip joint may be excluded by careful examination of that articulation, when it will be found that there is no limitation of movement at the hip such as is characteristic of disease there. The existence of sacro-iliac disease having been established it is then necessary to determine whether or not it is tuberculous, and in that regard it must be remembered that arthritis deformans may affect this joint, or again it may be the seat of gonorrhoeal arthritis. The history of the case will suggest the diagnosis in these cases.

The x-ray as an aid to diagnosis must not be overlooked; positive information may be obtained when disease is present. This consists mainly of the following: the definition of the cancellous bone is not clearly reproduced, the detail of the normal structure is lost, and there is a diffuseness in the picture of the osseous tissue which is in marked contrast to the clear reproduction of the architectural peculiarities of the bone which exist on the normal side.

Prognosis.—The prognosis in sacro-iliac disease is always grave, but the results of treatment in suppurative cases, which formerly were so unsatisfactory, are much better when these abscesses are treated in such a manner as to prevent mixed infection (*vide* page 677). It is not unusual to find that pulmonary tuberculosis is present, and under such circumstances the prognosis is extremely unfavorable because of the failure of general nutrition. The disease usually runs a chronic course, extending over some years, and the outlook must always be serious.

Treatment.—The principles of treatment laid down for tuberculous joints in general (page 586) must be employed here. It is difficult, however, properly to splint the joint. Rest in the recumbent position is necessary in the acute stage, and extension may be applied to the limb of the diseased side in order to steady it and, in turn, the affected joint. A double plaster spica extending from the middle of the calf of the leg up to the mammary line may be applied with advantage where the symptoms are very acute. Woven elastic trunks fitted about each thigh, and then about the buttocks and abdomen, have been suggested by Goldthwait and Osgood. This may be found particularly useful when the patient is able to move about. The same writers have recommended a sacral brace which is useful for conditions of abnormal mobility at the sacro-iliac joint, and which may be employed with advantage

in tuberculous disease. This brace is thus described: "It consists of a sacral pad to which a spring-steel crib is attached. The ends of the crib curve backward, and to these wide webbing belts are attached, which, when fastened in front, because of the curve in the crib part of the brace, crowd the sacral pad firmly against the upper half of the sacrum. The brace is kept in place by attaching it to the corsets by means of steels, and these not only hold the brace down, but, by steadying the lumbar spine, at the same time lessen the tendency to strain the sacro-iliac joints. In order to keep the apparatus in position when the patient is sitting, a narrow strap is attached at the base of the crib, which is tightened when the thighs are flexed and prevents the brace from springing away from the body. This brace, in connection with the elastic trunks in severe cases, has given relief when either alone was not satisfactory."

The joint may be fixed by other means, such as by the application of strips of adhesive plaster encircling the posterior and lateral portions of the pelvis and the lumbar spine, or a strong wide pelvic girdle may prove equally efficient.

When an abscess forms it must receive appropriate treatment, and should it increase in size it should be carefully opened and emptied of its contents; the walls of the abscess should be thoroughly curetted, and then the opening should be closed by sutures without drainage, so as to obtain healing by first intention. The method has elsewhere been described in detail (page 677). Every effort must be made to prevent mixed infection.

Where mixed infection has occurred and sinuses are discharging, then a free opening must be made to secure efficient drainage. Necrotic and carious bone must be removed. In some instances it may be necessary to remove large portions of diseased bone about this articulation. For this purpose Cheyne advises a "long curved incision with the convexity running along the middle of the sacrum and going well above the bones and over the sacro-sciatic notch. The flap is thrown outward and the glutei detached from the bone and also turned outward. The chisel is then applied to the ilium and the sacrum, and the bones chiselled away until the whole joint is excised, or till the bone deposit is found and removed." An operation of this magnitude is necessarily a very serious undertaking, as a patient requiring such measures, because of extensive and destructive disease in the joint, must already be much weakened by continued suppuration.

Tuberculous Disease of the Symphysis Pubis.—This joint is rarely the seat of tuberculous disease. It is not as important functionally as the sacro-iliac joint, as indicated by the fact that a sufficient degree of pelvic stability is preserved when the joint is deficient. Thus, in ectopia vesicæ the pubic symphysis is not present, and yet the individual is able to stand and walk in a normal fashion; so, too, congenital absence of the pubic bones, without interference with locomotion, has been recorded. The surfaces of the bones at the symphysis are covered with a layer of cartilage. Between these two surfaces

there is interposed a mass of dense connective tissue, partly fibro-cartilage, in the midst of which is a slit-like space running vertically and lying nearer the posterior than the anterior part of this so-called interpubic fibro-cartilage. An epiphysis is developed in connection with the cartilage over the pubis; this appears at puberty and unites at the age of twenty-five. The symphysis is surrounded by fibres which are attached to the bone and constitute the pubic ligaments which are situated on the various aspects of the joint. Of these the anterior is the strongest; the inferior ligament is also well developed, but the superior and the posterior are both weak.

Tuberculous disease in this locality does not, as a rule, present any peculiar feature. In one case, however, which was admitted to the Hospital for Sick Children, Toronto, the patient, a lad of seven years, was affected with tuberculous disease of this articulation; and, in connection with the disease, an abscess had formed, and a small sequestrum had ulcerated into the urethra and produced a urinary fistula.

The treatment of tuberculous disease of the symphysis pubis consists of rest in the recumbent posture when there is evidence of acute disease. Abscesses must be treated in the manner elsewhere described (page 677); and, should sinuses exist, free drainage must be provided after such operative measures have been adopted as may be necessary to remove diseased structures in and about the joint.

Tuberculous Disease of the Hip Joint.—This is by far the most common affection of the hip joint. In the Hospital for Sick Children, Toronto, of 249 cases admitted for surgical treatment of the hip joint, 225 (or 90 per cent) were for tuberculous disease. In the same institution tuberculous disease of the hip constituted a very large proportion of all joint affections (including the spine); thus, of 608 cases of surgical affection of the joints, 225 (or 37 per cent) were cases of tuberculous hip disease. These figures refer, of course, to children, and, in the hospital mentioned, the age limit for admittance is four years. While morbus coxae is undoubtedly more common in early life, and certain of the other affections of the hip are more frequently met with in the adult, still, when we include diseases of the adult in our statistical table, we find the proportion of tuberculous cases very high. Thus Koenig classifies 757 surgical affections of the hip as follows:

1. Tuberculosis.	568
2. Acute arthritis (after typhoid, scarlet fever, etc.)	110
Coxa vara	5
Tumor.	2
3. Gonorrhea	30
4. Arthritis deformans	22
5. Contracture and ankylosis from unknown cause	6
6. Pyæmic affections	3
7. Wounds (in dislocations and fractures)	11
	757

Koenig therefore found that 75 per cent of all surgical affections of the hip were tuberculous in character.

From the investigations of Whitman one is forced to conclude that coxa vara is much more common than these statistics of Koenig would lead us to believe.

Then, again, the cases of tuberculous arthritis admitted to the Children's Hospital, Toronto, being taken by themselves, it was found that hip-joint disease was the most common among these. The comparatively small record of 315 cases was as follows:

Hip-joint disease.....	179
Spinal disease.....	70
Knee-joint disease.....	52
Ankle-joint disease.....	9
Wrist-joint disease.....	4
Metacarpal disease.....	1

showing that, in all cases of tuberculous arthritis admitted, 53.6 per cent were affections of the hip joint. These statistics are somewhat at variance with those of Cheyne and others, who found that in children tuberculosis of the spinal column was the most common tuberculous bone affection. Cheyne found that from 40 to 46 per cent of all cases of tuberculous bone affection in children were located in the spine, while in my statistics only 22 per cent were spinal cases, and by far the largest proportion of cases were of disease of the hip joint. (See also the statistics given by Whitman, on page 602.)

The marked tendency for the disease to be restricted to the early years of life is shown by Koenig's statistics, as follows:

1-5 years.....	152
6-10 ".....	149
11-15 ".....	102
16-20 ".....	60
21-25 ".....	18
26-30 ".....	10
31-40 ".....	15
41-50 ".....	4
51-60 ".....	3
Not recorded.....	55

The immunity of older people from tuberculous disease of the joints may, however, be overestimated because of the fact that fewer people are alive at fifty than at ten years of age. Reference has been made to this fallacy at page 567. Certain authors have in fact held that the two extremes of life present the greatest liability to the disease, and experience would seem to show that this view is correct.

Anatomical Considerations.—The upper extremity of the femur at the time of birth is wholly cartilaginous: the trochanter major, the neck, and the head

form a continuous piece of cartilage which caps the osseous extremity of the shaft. The head lies in the acetabular fossa, and the acetabulum at this period of development is also cartilaginous to a very large extent. In Fig. 247 we have a frozen section through the hip joint of a child one year old; a centre of ossification has appeared in that part of the cartilage which is to form the head. The entire thickness of the floor of the acetabulum at its centre is seen to be cartilaginous; this constitutes the "Y cartilage," which persists between the individual elements of the hip bone which meet in the acetabular fossa. Osseous union of the three elements of the hip bone is not completed until the time of puberty. It is not until the sixth year that the extension from the shaft of the bone which forms the neck develops sufficiently to cut off the cartilage



FIG. 255.—Section through the Hip-Joint of a Child Nine Years of Age, showing the Epiphysis of the Head of the Femur separated from the Neck by Cartilage. (Original)

forming the great trochanter from that of the head; it is during the fourth year that an ossific centre for the trochanter appears. Fig. 255 is a photograph from a frozen section of the hip joint of a child nine years of age; it will be seen that the head is separated from the shaft by an epiphyseal line of cartilage. The layer of cartilage separating the head from the neck presents a curved outline in the section, the reason being that the layer of cartilage in question, with the adjacent portion of the osseous head, is concave toward the neck of the bone; this prevents separation of the epiphysis by traumatism, although separation along this line by tuberculous disease is not uncommon. The epiphyseal cartilage separating the head disappears at eighteen or twenty years of age; the cartilage separating the trochanter, at eighteen years of age.

The insertion of the capsule into the femoral neck and its relations to the neck and head are such that they must be studied and reckoned with in connection with articular disease. In the first place, it must be remembered that the acetabular cavity is considerably deepened by a strong circular fibro-cartilaginous ligament (the cotyloid ligament) forming the so-called glenoidal lip. The portion of the glenoidal lip which bridges over the cotyloid notch consti-

tutes the so-called transverse ligament. The articular capsule of the hip joint arises from the outer surface of the glenoid lip and surrounds not only the head of the femur, but the greater part of the neck. Anteriorly the capsule extends to the anterior intertrochanteric line and is attached there; posteriorly it does not extend quite so far. The result is that the whole of the femoral neck



FIG. 256. Section through the Hip Joint of an Adult, showing the Acetabular Fossa and the Ligamentum Teres. (Original.)

is embraced in the capsule anteriorly and somewhat more than half of it posteriorly. The articular capsule is strongly developed and it is markedly reinforced by accessory ligaments. These accessory ligaments are composed of longitudinal and circular fibres and are firmly adherent to the capsule. The orbicular ligament (the zona orbicularis of Henle) surrounds the narrowest portion of the femoral neck, constituting a very definite and important band of circularly disposed fibres. It is completely covered by the other ligaments

and surrounds the neck of the femur like a ring, being, however, most strongly developed above, behind, and below; it is attached to the bone below the anterior inferior iliac spine.

The longitudinal fibres constitute the ilio-femoral, pubo-capsular, and ischio-capsular ligaments. Of these the ilio-femoral is the most important; it passes from the anterior inferior iliac spine to the anterior intertrochanteric line, and in cases of effusion into the hip joint the tension upon this ligament has the effect of pressing the head of the femur into the acetabulum, the position of flexion at the joint is assumed in order that this ligament may be relaxed and the pain relieved. In three different localities the capsule of the hip joint is thin. On the posterior aspect a thin part exists above the zona orbicularis, between the ilio-femoral and the ischio-capsular ligaments. A second thin part exists in the lower part of the capsule below the zona orbicularis, between the pubo-capsular and the ischio-capsular ligaments. A third weak part exists on the antero-internal part of the capsule immediately internal to the ilio-femoral ligament, between this and the pubo-capsular ligament. This last weak spot on the anterior aspect deserves further notice because at this point the ilio-pectineal bursa, which lies between the ilio-femoral ligament and the ilio-psoas muscle, occasionally communicates with the joint cavity; according to Heinecke, the communication occurs in one in thirteen cases. Even where there is not an actual communication, the wall of the bursa on its deep surface is always thin, and it is not unusual for effusion of pus to make its way through to the bursa from the joint, or tuberculous invasion of the synovial membrane of the joint may here burst through and infect the lining of the bursa. It is said also that a psoas or iliac abscess may pass beneath Poupart's ligament and invade the hip joint by way of the ilio-pectineal bursa. Similarly, tuberculous disease may pass beyond the joint cavity at the other two weak points in the capsule, *i.e.*, at the thin part of the capsule on its posterior aspect, or at that already spoken of as being on its lower part.

The floor of the acetabulum is made up of two portions—a semilunar part, forming the upper and lateral portions, and, below it, a quadrilateral portion embraced in the concavity of the semilunar part. The lower extremities of the semilunar portion form the margins of the cotyloid notch. The quadrilateral surface referred to above differs from the semilunar portion in that it is not covered by cartilage, but has a rough and uneven surface; it is described as the *acetabular fossa*, and does not come in contact with the head of the femur, but is separated from the head by a cushion of fat covered by synovial villi. From this pad of fat and from the cotyloid notch arises the ligamentum teres, which in reality is a flat band, and not round. This ligament is inserted into a depression on the head of the femur (see Fig. 256) and further separates the head from the acetabular fossa. Nutrient vessels pass to the head of the femur in the round ligament. This seems to be the main function of this ligament, as

it serves no mechanical purpose in the hip joint, being too long and soft to take any part in checking joint movements. When tuberculous disease progresses to any marked extent in the hip joint, the ligamentum teres is soon destroyed and in cases which come to operation it is seldom distinguishable. Its early destruction in hip disease may be a factor in bringing about necrosis of the head in tuberculous disease because of the interference with the blood supply which must result. It is important to observe in this connection that this ligament is not always present in health, and, also, that its vascularity is lessened by, and may disappear with, advancing age. Tuberculous disease, however, invades the pad of fat and the synovial tufts connected with it. When these structures in the acetabular fossa are destroyed, the more likely is luxation of the joint to take place as the result of disease.

A bursa exists between the gluteus maximus and the posterior and outer part of the trochanter major. This is known as the *trochanteric bursa*. This bursa may be the seat of a cold abscess, and a fluctuating intumescence on the posterior part of the limb in this locality would suggest the probability of a tuberculous lesion in the trochanter, which lesion has invaded the bursa and has resulted in abscess formation. The bursa may similarly be invaded from a tuberculous lesion in the upper part of the femoral shaft, but it is not likely to be involved in disease confined to the joint cavity.

Etiology.—The factors which produce tuberculous disease in the joints have already been fully considered (*vide* page 564). Traumatic causes are those which receive most consideration as predisposing to the production of disease in the hip. Koenig's statistics would suggest that injuries are not so frequently the starting-point of this disease as is generally believed. He found a history of injury in only 15.1 per cent of his cases of hip disease. This percentage is, in our opinion, much too low; we agree with those who look upon trauma as a starting-point in the disease in a very large proportion of cases. We have discussed the relationship of trauma to tuberculous arthritis fully at page 565. Heredity played a part in the history of Koenig's cases in 35.4 per cent. Tuberculous hip disease has been known to follow scarlet fever, measles, whooping cough, diphtheria, chicken-pox, and typhoid fever. In a large proportion of the cases which come under observation, however, we are unable to obtain a history of any predisposing cause.

Pathology.—The tuberculous invasion of osseous tissue and of synovial membrane has been already described (page 573). In the hip joint the starting-point may be in the synovial membrane or in the bone. The origin is probably more frequently in the bone than in the synovial membrane. It would appear that the cartilage is never primarily affected. When the disease begins in the synovial membrane, it seems commonly to take its start from the synovial tufts which surround the ligamentum teres and from the pad of fat in the acetabular fossa. From these points the disease may rapidly

spread over the entire synovial membrane of the joint, but, because of the anatomical relations of the acetabular fossa and its contents (see page 627, also Fig. 256), we find that occasionally the disease spreads to the extra-articular tissues without invading the joint cavity, so that there may even develop an abscess which had its starting-point in the acetabular fossa and which may eventually come to the surface without any serious involvement of the hip joint in the disease. This possibility must be borne in mind in the operative treatment of cold abscesses. As already stated, the ligamentum teres disappears early in tuberculous invasion of the joint, and in cases which come to operation it is very rarely recognizable.

The disease as manifested in the bone may be solely in the form of caries, but the formation of a sequestrum is very common. The invasion may be primarily in bone; and, when that is the case, the deposit may be found in various localities. Thus, the disease may be located in the acetabulum or in the femur. When it is located in the femur we find that the head of the bone is the most frequent site. Caries may occur in the head and leave for a time the cartilage covering it intact; it is not uncommon to find comparatively normal cartilage completely separated from the diseased bone beneath. Eventually, however, the cartilage is involved secondarily, it becomes perforated in places, and is at last wholly destroyed. The primary focus in the bone may be in the neck, below the epiphyseal cartilage, or it may be removed a considerable distance from that cartilage and exist in the outer part of the femoral neck, or in the trochanter, or in the upper portion of the femoral shaft. On the acetabular side the deposit is frequently in the iliac portion of the bone. Sometimes, and the fact should be carefully noted, a tuberculous deposit may exist in the ilium quite above the acetabulum. The relative frequency of occurrence in these different localities may be judged from Koenig's statistics of his findings in 381 cases of excision of the hip joint. These are as follows:

Head of the femur	146
The acetabulum	187
The femoral neck	28
The trochanter	5
The femoral shaft	5
The pelvis above the joint	10
	381

Of the 146 cases in the femoral head it was found that—

The disease was primary in the head in	44 cases
The disease was secondary in the head in	48 "
The question was undetermined in	54 "

Of the 187 cases in the acetabulum—

The disease was primary in	98 cases
The disease was secondary in	49 "
The question was undetermined in	40 "

One would conclude from these results that primary disease in the acetabulum is more common than primary disease in the femoral head. This is quite contrary to the generally accepted belief that primary disease is more common in the head than in the acetabulum.

Definite statistics are not available to show the comparative frequency of primary disease in the bone and in the synovial membrane, respectively. Clinical observation made with a view to determine this point is not easily carried out in the hip, but the view generally held, and in which we concur, is that the bone is more commonly the seat of the primary deposit.

The disease in the joint may progress until more or less complete disintegration of the joint structures occurs. Destruction of the articular cartilage takes place with absorption of the osseous elements entering into the joint structure. By reference to Figs. 247, 255, and 256 it will be seen that the head of the femur presses upon the upper part of the acetabulum, and the overlying thickened iliac portion is the part which receives the pressure of the head. So it is we find that the tonic contraction of the muscles in hip disease produces its effect by pressure in the direction indicated, and there occurs an absorption of the upper and back part of the acetabulum with a travelling of the head of the femur upward and backward upon the dorsum ilii; a growth of new bone may make an osseous ridge against which the dislocated head impinges at a higher level. This has been described as enlargement or "wandering of the acetabulum." Occasionally something approaching the conditions found in true dislocation obtains, so that the head is dislocated out of a comparatively normal acetabular fossa. This occurs as the result of the growth, in the joint cavity, of tuberculous tissue which fills up the acetabulum and thus dislodges the head of the bone, the diseased and softened ligaments permitting the head to pass upward over the upper rim of the acetabulum on to the dorsum ilii. This may the more readily occur when there is partial or complete disappearance of the head as the result of disease; under such circumstances the upper portion of the neck may ride on the dorsum of the ilium. Occasionally the head is detained against the acetabular margin, which becomes grooved at the point of pressure. Rare instances are on record where the head of the bone has been dislocated in other directions; thus Cheyne observed two cases where it had passed forward on to the pubis.

Chronic abscesses are very common in hip-joint disease. When these originate within the joint cavity they are likely to rupture through the capsule at its weak points (page 627) and appear on the antero-internal aspect or posteriorly. The abscesses spread in the direction of least resistance; thus, when appearing anteriorly, they often pass between the gluteus minimus and the rectus tendon and then between the tensor fasciæ femoris and the sartorius, and thus reach the fascia lata and the surface; on the inner aspect an abscess may pass down among the adductor muscles toward the knee. Posteriorly the

abscess may burrow among the glutei muscles. The pus may invade the iliopsoas bursa and spread upward under Poupart's ligament, there forming an iliac abscess. Then, again, perforation of the floor of the acetabulum, or acetabular disease short of perforation, may give rise to a pelvic abscess which proceeds to occupy the iliac fossa, or may spread downward into the ischio-rectal fossa or pass out through the sacro-sciatic foramina to point in the gluteal region. When the disease is in the outer part of the femoral neck or in the trochanter, there may develop, in connection with it, an abscess that has no communication with the joint cavity.

Symptomatology.—The disease is frequently very insidious at the onset. The first symptom of trouble to attract attention is the existence of a lump when the child walks. Pain is occasionally an early manifestation of the disease, but it is frequently so insignificant that no complaint is made and the existence of pain or tenderness is found only on examination; even then one may fail to elicit it. Restriction of the normal movements of the joint exists to a greater or less degree. The limb is caused to assume a characteristic attitude of flexion abduction and rotation outward. Muscular atrophy is found when one compares the measurements of the diseased side with those of the sound side. As the disease progresses, and destructive changes occur in the joint, one finds that the attitude of the limb is altered; it becomes adducted and inverted, flexion still persisting. Pain may be greatly increased or may still be slight in degree. In a great many cases the limb is rotated outward instead of inward in this late deformity; this is apparently the case, at all events, when dislocation on to the dorsum ilii has not yet occurred. Abscesses may form and there may be marked constitutional disturbance. It may be well to discuss these various symptoms individually and to indicate their significance during the various stages in the progress of the disease.

Lameness.—The child limps, and this in many cases is the first noticeable symptom. This limp may be assumed without any conscious knowledge on the part of the child that he is thus in a mechanical fashion protecting the hip joint. When asked why he limps he may be unable to explain. The limping is, as a rule, more marked in the morning, often apparently disappearing during the day; the patient tends to throw his weight upon his toes rather than jar the sensitive hip by coming down upon the heel; he does not fully extend the hip while walking, the knee being slightly flexed, and he maintains his weight for a shorter time on the diseased limb than he does on the sound limb. The lameness may be intermittent in character, and so the mere absence of a limp at the time of an examination should not exclude hip-joint disease from one's diagnosis. At later periods of the disease lameness may be the result of deformity of the limb; thus there may be shortening or dislocation to account for it; in certain cases ankylosis is the cause of the disability.

Pain.—This is a variable manifestation of hip disease. It may be entirely

absent at first, and the disease may make considerable progress without inducing pain. On the other hand, pain may be the first symptom to attract attention, and in acute cases it may be very severe. There are certain characteristic features of the pain in hip disease; of these the one most worthy of note is the reference of pain to the knee rather than to the hip. This has proved so misleading that the knee has frequently been assiduously treated on the false assumption that it was the seat of trouble, when a careful examination would have revealed the fact that hip disease was the cause of the referred pain. The associated nerve supply of the two joints is accountable for the error. Branches from the anterior crural, the obturator, and the sciatic nerves supply the hip

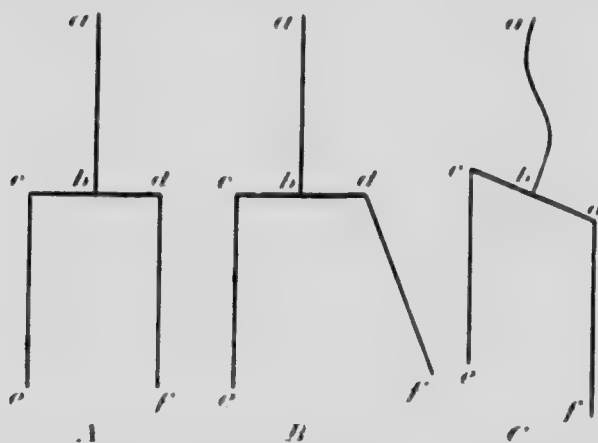


FIG. 257. Diagram Representing the Attitude of Abduction. The figure is explained in the text.

joint, and these three nerves are again represented in the knee joint. It further has been claimed that the pain induced along the course of any one of these nerves individually may aid us in diagnosing the starting-point of disease in the hip. Thus, the ligamentum teres receives its nerve supply from the obturator, and the geniculate branch of the same nerve passes to the inner side and to the interior of the knee joint; if the ligamentum teres is the part primarily involved at the hip, then, while the disease is restricted to the region of that ligament, pain is complained of at the knee on the inner side of the joint and in the interior thereof. If again the anterior part of the joint is affected, *i.e.*, in the region supplied by the anterior crural, then the referred pain at the knee is experienced on the anterior part of the joint. When the posterior part of the capsule of the hip is affected, then pain may occur at the back of the knee and may even extend to the heel or into the foot. It must not be supposed that pain in the knee is an invariable accompaniment of hip disease, for such is not the case. The pain may be restricted to the hip.

The pain in hip disease is not constant and is often induced by some sudden

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movement, or it may occur quite spontaneously without any apparent exciting cause. In children "night cries" constitute a distressing manifestation of pain. The child will suddenly cry out, will waken from sleep, and may often be found holding the thigh in a firm grasp. At other times a sharp cry occurs during sleep which is uninterrupted. It has been claimed that the night cry indicates implication of the articular cartilage in the disease, but there is no



FIG. 258. - Tuberculous Disease of the Hip in a Child aged Six Years. The attitude of abduction and outward rotation is shown by means of tapes placed over the axes of the limbs and between the anterior superior iliac spines. (Original.)

good ground for this assumption. The sudden pain during sleep is due to the contraction of muscles which during the waking hours have been on guard but have become relaxed during sleep, and then, because of some sudden muscular spasm, the articular surfaces of the hypersensitive joint are pressed together and pain is produced. Night cries may be repeated frequently—so many as fifteen or twenty times during the night.

The intensity of the pain varies greatly. In very acute cases it may be severe, so much so that the slightest change in position may cause great suffering. During the manipulation necessary for the examination of the joint, pain may be produced by pressure upon the trochanter, or the whole limb, grasped

at the ankle, may be suddenly jerked upward so as to cause sudden pressure between the joint surfaces. Pressure anteriorly over the joint frequently elicits pain.

The Attitude of the Limb.—In the early stages of hip-joint disease the limb is caused involuntarily to assume a characteristic attitude. Flexion, abduction, and rotation outward are brought about. When the limbs are



FIG. 259. The Same Patient as Fig. 258. The picture shows that, when the limbs are brought into a position in which they are parallel, the angle of abduction is preserved and apparent lengthening is produced. (Original.)

brought parallel with one another and the angle of abduction is preserved, there must necessarily be, as a result, an apparent lengthening of the affected limb. Reference to Fig. 257 will at once make this clear. In the figure the line *ab* represents the axis of the spine, *cd* the transverse axis of the pelvis, and *ce* and *df* the axes of the lower extremities. In A the normal relations of these axes to one another are represented; in B the relation which obtains in abduction of the left lower limb is shown. In C the limbs are brought into a position in which they are parallel, and as a result, there is apparent lengthening of the abducted limb with tilting of the pelvis, inducing secondary lateral curvature of the spine, while the angle of abduction is maintained.

Thus it will be observed that abduction may be masked by the tilting of the pelvis. The tilting of the pelvis is best estimated by observing the height of the anterior superior spine of the ilium on the abducted side, which will be found at a lower level than on the sound side. Figs. 258 and 259 are photographs of the same patient; in the former the affected limb is abducted from its fellow and the pelvis is straight, while in the latter the limbs are brought together and the angle of abduction is preserved by tilting the pelvis. The amount of apparent lengthening may be estimated by measuring from the umbilicus to the internal malleolus on the affected side and comparing that with a similar measurement on the sound side. The real length of the limbs will be determined by placing the two limbs in the same degree of abduction and the same degree of flexion, and measuring from the anterior superior iliac spine to the

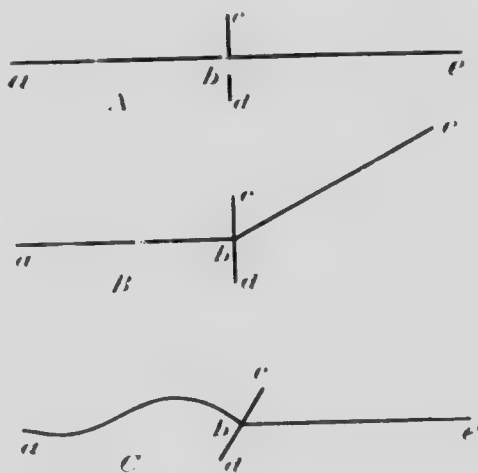


FIG. 260. Diagram Illustrating the Attitude of Flexion. The figure is fully described in the text.

internal malleolus. In the existence of apparent lengthening there may still be real shortening. Thus Koenig found real shortening in 83 out of 267 cases in which abduction existed, *i.e.*, thirty-one per cent.

Flexion at the hip may similarly be masked by tilting the pelvis on its transverse axis and curving the lumbar spine. Fig. 260 illustrates the method of bringing this about. The line *ab* represents the axis of the spine, which, for the purpose of illustration, may be considered a straight line; *cd* represents the antero-posterior axis of the pelvis, and *be* the axis of the limb. The normal relations of these axes in the supine position is shown in A; while in B the axes are shown in the relations they would bear to one another when the lower limb is flexed. When, however, the limb lies flat upon the table the angle of flexion is preserved by tilting the pelvis, the effect of which must necessarily be to throw the base of the sacrum forward and to produce a lordosis of the lumbar spine. Fig. 261 is a photograph of a patient showing flexion

The boy is lying flat upon a table, and the lordosis of the lumbar spine is indicated by the tapes attached to his body. If the limb is raised, the angle of flexion is preserved by tilting backward the pelvis on its transverse axis, when the lordosis disappears, the back lying in contact with the surface of the table. This attitude is illustrated in Fig. 262. The angle of flexion may now be calculated by using a goniometer, as shown in the figure. More accurate measurements may be obtained by eliminating the effect of extension of the sound limb, and in Fig. 263 this method of determining the degree of fixed flexion of the hip, as suggested by Whitman, is indicated. The sound limb is flexed acutely so as to hold the lumbar spine in contact with the table, the diseased limb rises up and is maintained in its attitude of fixed flexion, and the angle of flexion of the diseased side is then estimated.

A certain amount of lordosis is normal in the lumbar spine, and, where the



FIG. 261.—The Same Patient as Fig. 262. The illustration shows the lordosis of the lumbar spine when the limb is brought down flat upon the table. (Original.)

buttocks are unusually well developed, a space may exist between the lumbar spine and the table even when the thighs are extended. This fact must be remembered if we wish to prevent error in our conclusions.

This attitude of flexion, abduction, and rotation outward is the natural resting position of the limb. Thus, if one recalls the characteristic attitude of ease assumed by an individual while sitting upon a chair, it is seen that the thighs are abducted from one another, there is a slight rotation outward, and there is flexion at the hip joint. It seems, therefore, natural that in conditions of disease, when nature demands rest, this characteristic attitude should be assumed. The experiments made by Bonnet many years ago throw some light upon the assumption of this attitude in early hip-joint disease. Bonnet injected the healthy hip joint in a cadaver, under pressure, and found that it assumed a position of flexion, abduction, and rotation outward. The experiment is not as conclusive, however, as might appear at first sight, because a very considerable degree of pressure is necessary within the capsule in order to produce the attitude in question in the cadaver. In the presence of effusion into the joint

one would expect this attitude in order to accommodate the joint cavity to the effused material, and this is undoubtedly the case in acute synovitis. In hip-joint disease, while there is seldom, if ever, much effusion, nevertheless the thickening of the synovial membrane, where that exists, or the sensitiveness of the joint structures, may have the same effect. Flexion, rotation outward, and abduction relax the strong ilio-femoral ligament, and this is probably the true explanation of the assumption of the attitude in question; the sensitive structures are protected from pressure, and, while a considerable degree of movement may be carried out painlessly, nevertheless any attempt to produce



FIG. 262. Tuberculous Disease of the Hip in a Child Six Years of Age. The amount of flexion is calculated by means of the goniometer. The limb is elevated until the spine lies flat upon the table, when the angle of flexion is estimated. (Original.)

full extension or complete adduction is resisted and produces much pain. It is obvious, also, that with the thigh flexed there is less jar produced in the sensitive joint when the patient moves about.

In some instances, even in the early stages of the disease, the thigh is flexed, rotated outward, and adducted instead of abducted; this may occur when the process is very acute, and we may imagine that in such cases early extensive destruction has been done to the joint tissues, resulting in softening of the ligaments and thus permitting the joint to assume this attitude through muscular spasm without inducing the tension within the joint which demands abduction under other conditions. The attitude of adduction and inward rotation with flexion is, however, a very constant condition in the later stages of the disease when there has been absorption of the head of the bone, or when the

acetabulum is altered in shape, and when dislocation of the femur on to the dorsum of the ilium takes place. This attitude of adduction and flexion is well shown in Fig. 283, which represents a patient in whom the disease had become quiescent. In this case, however, the limb is rotated outward. The assumption of this attitude is purely mechanical in nature, and may be compared to the position of the limb in an ordinary traumatic dislocation on to the dorsum ilii of a healthy joint.

Fig. 264 shows a patient with adduction and inward rotation with tilting upward of the pelvis on the affected side. If in this patient the foot of the adducted limb were carried across the foot of the opposite side, the pelvis



FIG. 263. The Same Patient as in Fig. 262. The illustration shows Whatman's method of determining the amount of flexion by flexing the other thigh so as to hold the lumbar spine in contact with the table. (Original.)

would be restored to its normal position, and the angle of adduction would be preserved. If the adducted limb were carried away from its fellow, the angle of adduction would still be maintained by tilting the pelvis markedly upward on the affected side. In these cases the effect of adduction with tilting upward of the pelvis on the diseased side is to produce apparent shortening of the affected limb. This may be estimated in the same fashion as that suggested in apparent lengthening. Along with the apparent shortening there may be, and probably is, real shortening because of absorption of the head, of shortening of the neck, or of changes in the acetabulum with dislocation upward and backward. Koenig found that out of 232 cases in which adduction was present there was real shortening in 164, *i.e.*, seventy-one per cent.

While we have thus described the characteristic attitudes assumed in the different stages of hip-joint disease we must record the fact that some departures from the usual conditions are occasionally noted. For example, if the patient is confined to bed or does not walk, as in hip disease in infancy, the attitude of abduction may persist, even when the muscular spasm is intense. Thus it would appear that locomotion has a distinct influence on the character of distortion. (Whitman.) Then, again, while the abducted limb is usually rotated outward and the adducted limb rotated inward, the reverse may be the case. These unusual conditions are probably the result of the special treatment to which the joint has been subjected. It is a question whether or not internal rotation actually exists in the adducted cases. I have observed many instances where the reverse was true, and, curiously enough, most of the patients photographed and published do not show the internal rotation which is ascribed to them. Lastly, it may be noted that Koenig reported three cases in which real lengthening of the affected limb was observed.

When abduction, flexion, and rotation outward exist, the buttock is flatter and broader on the affected side than on the sound side; because of the flexion the gluteo-femoral furrow is shallower, or may become completely obliterated, while the tilting downward of the pelvis causes it to be lower than its fellow of the opposite side. On the other hand, in adduction this furrow is shortened and elevated, on the anterior aspect of the limb the inguino-femoral furrow is deeper and longer in adduction and flexion, while abduction tends to make it less marked. The intergluteal furrow and the genitals point away from the abducted thigh and toward the adducted thigh.

Restriction of Movement.—This is a characteristic phenomenon in all cases of tuberculous arthritis. The characteristic attitudes assumed by the limb at the various stages in the development of the disease have been described.



FIG. 264. Tuberculous Disease of the Left Hip in a Child Aged Seven Years. The picture shows abduction with tilting upward of the pelvis on the affected side. (Original)

Thus, in the early stages, when the limb is in a position of abduction, flexion, and rotation outward, limitation of movement is a very characteristic feature of the case. It must be remembered, however, that movement within certain limits may be very free, and the importance of this observation cannot be too strongly urged, as an error in diagnosis may be made, because it might be assumed that disease could not exist where such free movement is possible.



FIG. 265. Ankylosis with Flexion Deformity in Hip Disease. The patient was eight years of age; the disease was of four years' duration. When the lumbar spine is straight, as in the figure, the degree of flexion at the hip becomes evident. (Original.)

But careful examination will show that there is very definite restriction of movement at this early stage. The restriction, however, takes place at the extreme limits of the arc of motion. Thus we find that full extension is impossible if a definite amount of flexion persists; the degree of this is determined by the methods already alluded to; full flexion on the abdomen is also impossible. So is it also with extreme adduction or full abduction; these movements are resisted. Similar observations may be made regarding the move-

ments of rotation. The resistance offered to these various movements is produced by muscular contraction.

In later stages of the disease, when the symptoms are more acute and considerable damage to joint structure has occurred, the attitude of adduction and flexion may be rigidly preserved by tonic contraction of the muscles, and any attempt to alter the position of the limb is promptly resisted by reflex



FIG. 266. The Same Patient as in Fig. 265. The picture illustrates the loss of the lumbar spine when the patient is standing upright upon the affected limb. (Original.)

muscular spasm. Under an anæsthetic these movements may be carried out much more freely, the resistance being greatly diminished when the limb is examined under these conditions. In the absence of anæsthesia any attempt to force the limb from its assumed position results in movements of the pelvis along with the femur, movements which are made for the purpose of preserving the angle of flexion and adduction. These movements of the pelvis, while passive

manipulation of the limb is being carried out, are dependent upon the sensitive-ness of the diseased hip joint and must be eliminated in our estimation of the actual amount of movement possible at the hip joint.

At this later period of the disease there may exist actual mechanical resistance to movement, as, for example, in dislocation on to the dorsum ilii, or there may be fibrous or osseous ankylosis to account for rigidity. In ankylosis the limb may be fixed in a faulty position in cases that have not been cared for during the earlier stages of the disease; Figs. 265, 266, and 283 illustrate cases of this kind. In Fig. 266 it is observed that the limb can be brought to the ground for purposes of support only by tilting the pelvis and arching the lumbar spine.

Atrophy of the Limb.—The atrophy of the muscles of the limb is an essential accompaniment of tuberculous arthritis. This is noticeable both in the gluteal region and in the thigh and leg. Circumferential measurements will indicate the degree of atrophy present in the thigh and leg, and the flattening of the buttock is also largely produced by muscle atrophy. It would appear that the muscle atrophy is more marked in synovial disease, but it occurs in all joints affected by tuberculous disease. The cause of muscle atrophy is discussed elsewhere (page 583); failure of nutrition producing atrophy is probably mainly due to some reflex nervous influence. This failure of nutrition is also to be observed in the bone, which, in advanced disease, is atrophied often to an extreme degree (see Fig. 249 and Fig. 290). In the late stages of the disease, and particularly when ankylosis is present, disuse is undoubtedly an important factor in the production of atrophy. Comparative measurements here, too, will show increased disparity between the two limbs because of the hypertrophy of the sound limb caused by the increased amount of work thrown upon the muscles of the sound side. The atrophic condition of the muscles is frequently very readily appreciated by handling the limb, when the atrophied muscles are obviously in a flabby condition as compared with those of the sound limb. The nutrition of the skin is also impaired and becomes thinner than normal.

Shortening of the Limb.—In the early stages shortening of the limb is not present, but it is a very constant condition after the disease has progressed for any great length of time. The disparity in length of the two limbs in an individual who has suffered from hip-joint disease is due, on the one hand, to pathological changes at the joint, which bring about actual shortening, and, on the other hand, to arrest in growth (in length) on the affected side while the sound limb lengthens and thus increases the disparity between the two. The pathological changes at the joint which lead to shortening are chiefly those causing absorption and disappearance of the head of the bone, with changes in the neck, resulting in shortening of the neck and an alteration of the angle which the neck forms with the shaft; this angle is reduced in disease; further,

the alteration in the shape of the acetabulum, permitting the changes which, when extreme, constitute complete dislocation of the head on to the dorsum ilii. In rare cases it is said that the acetabulum has been perforated and the shortened head and neck have passed through into the pelvis, thus increasing the shortening. Short of actual perforation, the acetabulum may be sufficiently eroded and deepened to cause diminution in the length of the limb. Then, too, the epiphysis separating the head from the neck may be destroyed and cause arrest of growth in length at this point, resulting in diminished length on the diseased side as compared with the sound side. Lastly, the failure in nutrition of the whole limb would necessarily affect the growth in length of the affected side and would cause the limb to remain shorter than its fellow. The foot may participate sufficiently in this failure of nutrition to show a marked degree of shortening and diminished size.

In taking measurements of the length of the limbs it is important to see that the two limbs are in exactly the same position as to flexion, abduction, etc.; otherwise the results obtained will be erroneous.

The amount of shortening due exclusively to changes at the seat of disease in the hip may be estimated apart from that due to interference with the growth of the limb. Nélaton's line may be used for the purpose: a line is drawn from the lowest point of the anterior superior iliac spine to the most prominent point on the lower and posterior surface of the tuberosity of the ischium. Under normal conditions the tip of the trochanter will touch this line, but when there is shortening the trochanter will come to lie at a higher level, and the amount of shortening so indicated will represent that due exclusively to changes at the hip. This may be compared with the shortening of the entire limb, which may be ascertained, as already indicated, by measurement from the anterior superior spine of the ilium to the internal malleolus. Another method of estimating the shortening due to changes at the hip is by determining the relative distance of the trochanters from the middle line of the body. This may be done by using calipers for the purpose. It must be noted, however, that if true dislocation has occurred on to the dorsum ilii, the trochanter on the diseased side may not be nearer the middle line than its fellow.

Koenig, in estimating the frequency of shortening as a result of hip disease, found that it existed in 52.1 per cent of his cases. Where resection had been resorted to, there was shortening in 69.4 per cent of the cases; while where conservative treatment had been adopted, the percentage of cases in which shortening occurred was only 36.1. These figures are, however, not necessarily in favor of conservative treatment, because the conditions which made resection advisable, in all probability induced a greater degree of shortening. Koenig's observations were made by measuring the height of the trochanter in relation to Nélaton's line. Apart from these considerations, however, there can be no doubt of the fact that the best functional result is attained by conservative

treatment, and resection must be resorted to only when demanded by conditions which will be discussed in the section on treatment.

It is quite impossible to state the degree of shortening which remains permanently in individuals who are the victims of hip disease. The greatest disparity in length of the two limbs is, of course, possible where the disease occurs in the young growing child, because the development of the diseased limb does not keep pace with that of the healthy one. It also obviously depends on the amount of destruction of the bones at the hip, and the possible displacement of the head of the femur from the acetabulum. The extremes may be suggested by stating that as much as five or six inches of shortening has been recorded as the final and permanent result of hip disease; it is rare to have shortening to such an extent, however, and, fortunately, a large proportion of our patients recover without any shortening whatever.

Lengthening of the Limb.—Real lengthening of the limb occurs as a rare manifestation of disease at the hip. It simulates a condition which is much more common as the result of disease at the knee joint. The cause of real lengthening may be found in an increased activity of growth at the epiphyseal cartilage; this increased activity may be induced by the hyperæmia which affects the tissues in the neighborhood of the tuberculous focus. It is also suggested that the formation of diseased tissue in the bottom of the acetabulum may force the head of the bone downward, and thus bring about a certain amount of lengthening of the limb.

Abscess.—The occurrence of chronic abscess in tuberculous hip disease is frequent. Koenig's statistics of 568 cases showed that abscess occurred in 324, *i.e.*, 56.5 per cent of the patients. The position of the abscess was recorded as follows:

On the inner side of the thigh (limited toward the outer side by the femoral vessels)	26 cases
On the anterior aspect of the thigh (limited externally by a line drawn vertically through the anterior superior iliac spine)	126 "
On the outer side of the thigh (in the region of the trochanter)	65 "
On the posterior aspect of the thigh	49 "
In the pelvis	41 "
Situated over the pubis	5 "
Large abscess surrounding the thigh or passing down the thigh toward the knee	4 "
Cases in which the location was not stated	7 "

From these statistics it is obvious that an abscess on the anterior aspect of the thigh is much more common than elsewhere, and that such is the case is proved by general observation. The age of the patients in whom abscess formation occurs has also been noted by Koenig, and his results may be tabulated as follows:

Age.	No. of cases observed	No. of these cases in which abscess is formed	Percentage of occurrence
0-5	103	62	60.2 per cent
5-10	167	95	56.9
10-15	116	68	58.6
15-20	93	44	46.2
Over 20	73	44	60.3
Age not recorded	16	9	56.2

From these statistics it is obvious that the tendency to the formation of a chronic abscess is shared fairly evenly by individuals at all ages. From fifteen to twenty, however, there is the greatest degree of immunity, while at the extremes of life the tendency to abscess development is most marked.

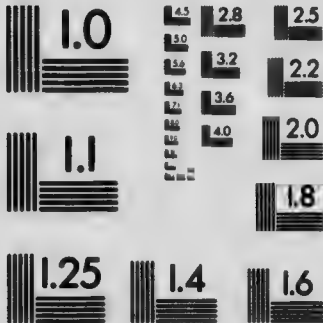
The clinical signs indicating the formation of an abscess are those of a fluctuating tumor in one of the localities mentioned about the diseased hip. The origin and course of these abscesses have already been discussed (page 630), and the pathology has also been described (page 580). There may be no warning whatever of the formation of the abscess, and its existence may be discovered in a purely accidental fashion. It thus becomes important to examine patients under treatment in a routine manner from time to time for the purpose of determining whether or not an abscess is forming. Not only is it necessary to examine the region of the thigh about the hip, but the iliac fossa must be palpated, and, if necessary, a rectal examination should be made if one suspects the existence of an abscess in the true pelvis. By digital examination through the rectum one can determine a thickening of the tissues, or the presence of an abscess in the region of the acetabulum. While the onset of abscess formation may thus be insidious, yet in acute cases and particularly where the patient is not being properly cared for, there may be much pain and other serious symptoms attendant upon its formation. Pain, elevation of temperature, and increased muscular spasm may be present, and abscess formation may be found to be the cause of this exacerbation of acute symptoms.

As long as the abscess remains of a purely tuberculous nature the course of the disease may not be influenced by its formation, but the great danger is mixed infection, and if this occurs the case at once assumes a much more serious aspect, and the chance of securing and maintaining functional efficiency of the joint is greatly lessened because extensive destruction of joint structure is commonly the result of such mixed infection. A purely tuberculous abscess may be efficiently dealt with by operative means, as we shall see, but once mixed infection has occurred, then we have, as a result, discharging sinuses which may persist for long periods, and the patient suffers from the usual sequence of events which supervenes from long-continued suppuration: there is failure of the general nutrition, with, later on, visceral amyloid disease and possibly fatal results. This train of symptoms often has its inception in the formation of a chronic



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abscess, and the unfortunate results may often be prevented by early detection of the abscess and by the employment of efficient treatment soon after it begins to develop. A case illustrating the existence of many sinuses and of extensive joint destruction is shown in Fig. 267, which represents a lad of

fourteen who had had discharging sinuses for ten years with ankylosis of the hip in a position of flexion and adduction.

Localized Swelling.—There may be some fulness, particularly on the anterior aspect of the thigh, about the hip. This may be due to infiltration of the tissues about the joint, and is most frequently appreciable in synovial disease where the ligaments have become the seat of inflammatory swelling. Fulness about the hip may also be due to abscess formation.

Constitutional Symptoms.—The constitutional manifestations in hip disease vary within wide limits. The symptoms are often so slight as to avoid detection altogether. The temperature may be slightly elevated, but this is seldom the case except where marked indication of an acute process is evidenced in the local trouble. Where the disease is getting progressively worse there is failure of general nutrition, but it is often difficult in such cases to distinguish between cause and effect. It may be that a lower

state of vitality and diminished power

FIG. 267.—Tuberculous Disease of the Hip Joint. Ankylosis in faulty attitude of Marked Flexion and Adduction, with numerous discharging sinuses. The patient was fourteen years of age and had suffered from trouble in the hip for ten years. (Original.)

of resistance are accountable for the fact that certain individuals fall easy victims to the disease, once infection occurs. On the other hand, the local disease may react upon the individual so as to impair his general health. Pain may interfere with sleep, and, in certain cases, confinement to bed and the impossibility of taking exercise in the open air may result in general nutritional disturbance with loss of flesh and general malaise. Marked constitutional effects are produced when mixed infection occurs in a tuberculous abscess, so that, while such an abscess remains unopened, there are elevation of temperature, quickened pulse, and other indications of septic absorption.

Diagnosis.—Systematic and careful examination of the hip must be carried out in order to determine the existence or otherwise of the local manifestations of disease which have been described. A patient the subject of hip disease, seeking advice, may not refer the trouble to the hip at all, but may imagine that it is located elsewhere; the most notable example of this is where the pain is referred to the knee. Examination of both joints in such cases will show that the knee is healthy, while disease in the hip will become manifest. It is important to note the attitude assumed by the patient while standing and walking as well as that maintained when he is lying down. The comparative length of the limbs and the circumferential measurements must be ascertained. Real shortening is determined by measuring from the anterior superior iliac spine to the internal malleolus or by ascertaining the relative height of the trochanter major in relation to Nélaton's line. Apparent lengthening or shortening is found by measuring from the umbilicus to the internal malleolus. In taking these measurements it is necessary to make sure that the sound limb has not previously been the seat of disease or of injury; under such circumstances it is useless for comparison. Fig. 286 illustrates the case in point: it is that of a child suffering from hip disease of the left side with knee trouble on the right side. Neither side would give us normal measurements. Occasionally there is double hip-joint trouble, to complicate matters. Where trustworthy comparative measurements are not available we must rely on other means for establishing a diagnosis. In order to determine faulty attitude the patient should be made to lie upon a flat and firm surface such as a table or a firm mattress; there must be no yielding to pressure of the surface upon which he lies. The degree of flexion, abduction, etc., may then be determined by the methods already referred to. It may be noted here that when the angle of flexion is very small it may best be appreciated by placing one's hand, with its dorsum on the table, under the patient's back in the lumbar region, and then causing the patient to flex first the sound and then the diseased limb at the hip. When the sound limb is flexed, no increased pressure is appreciated on the hand; but the moment the diseased limb is flexed, one immediately appreciates pressure upon the hand in the loin. The slight amount of lordosis which exists is obliterated whenever the diseased limb is flexed, but it is preserved while that limb is extended: hence the explanation of the increased pressure of flexion. The existence of tuberculous disease elsewhere or a strong family history of tuberculosis would suggest the nature of one's diagnosis, but it must be remembered that hip-joint disease is often a purely local manifestation and may occur in individuals otherwise apparently healthy.

The *x*-Ray as an Aid to Diagnosis.—This may be of great value in individual cases by giving us positive information of disease. On the other hand, negative results do not by any means exclude the existence of a tuberculous focus. A skiagram is best studied by viewing the photographic plate by transmitted

light. These plates, when reproduced in the form of a print cannot give the fineness of detail which is appreciated in a well-illuminated x-ray negative. The illustrations here given in Plate XXIV, Figs. 1 and 2, indicate the kind of information which may be derived from a skiagram. The patient was a lad fifteen years of age, who for six months had complained of slight pain in the left hip and lameness. These conditions were not constant, but intervals of freedom from all discomfort occurred. Examination disclosed a slight degree of atrophy, with some restriction of movement, but no appreciable shortening. The skiagram showed a tuberculous focus in the upper part of the left femoral neck, with very noticeable shortening of the neck: the head of the bone and the acetabulum were normal and there was no evidence of disease in the synovial membrane. The diagnosis here was made of a localized deposit in the neck of the femur. With rest and appropriate treatment the lad recovered. It is essential in these cases, if we are to get the maximum benefit of this method of diagnosis, to prepare two plates, one of each side, and thus be able to compare the diseased side with the normal side. In Plate XXIV this comparison may be made. In tuberculous affection of the bones and joints the x-ray picture may demonstrate, among other things, atrophy of the bone (Plate XXVI and Fig. 290), abscess in bone (Fig. 254), the existence of a sequestrum (Plate XXV), and loss of a well-defined contour of the articular extremities of the bones entering into the joint structure (Figs. 253 and 290). It must be remembered that an old, healed tuberculous lesion may show up in the radiogram. The x-ray method of examination has been used as a means of studying the progress of these cases and for determining the effect of our therapeutic measures (Freiberg). The x-ray must therefore be looked upon as of positive value in diagnosis, but we must remember that it is merely an important adjunct to careful clinical methods of examination which must not be neglected in any detail.

Tuberculous disease at the hip may be confounded with other affections, and we may now observe certain points in differential diagnosis which are worthy of note.

Injury to the Hip.—Injury may be the starting-point of actual tuberculous disease, and this fact must be borne in mind in the individual cases which come under observation. Synovitis may result from traumatism, or there may be congestion in the osseous tissue; the muscles, too, about the joint may be strained or bruised. The local signs of trouble usually supervene almost immediately after the injury. The disability present may closely simulate hip-joint disease, and an immediate positive diagnosis may not be possible. Such cases must be kept under careful observation in order to establish an accurate diagnosis; in the absence of tuberculous trouble the symptoms will usually disappear after rest in bed for a few days.

Fracture of the Neck of the Femur.—Whitman has shown that fracture of the neck is much more common in children than has hitherto been supposed

EXPLANATION OF PLATE XXIV.

The radiograph illustrates tuberculous disease in the left hip joint. There is considerable shortening of the neck of the femur, as is evident when one compares the diseased side (Fig. 1) with the sound side (Fig. 2). The head of the bone and the acetabulum appear normal, but a tuberculous deposit is seen in the upper part of the neck of the femur. The patient was fifteen years of age and had complained of slight pain in the left hip for six months previous to observation; lameness manifested itself in an intermittent fashion; during the intervals he suffered no disability. Examination showed the characteristic muscle atrophy in the limb and limitation of movement. Under appropriate expectant treatment the patient recovered.

The x-ray picture was reproduced by Dr. S. Cummings, of Toronto, under whose care the patient was treated and to whom the author is indebted for both the photographs and the history of the case.

FIG. 1



FIG. 2



RADIOGRAPHS ILLUSTRATING TUBERCULOUS DISEASE IN THE
HIP-JOINT IN A PATIENT 15 YEARS OF AGE



The fracture is usually of the green-stick variety, without separation of the fragments, but with change in the angle of the neck. Often the patient is able to get about and use the limb soon after the injury, but he suffers pain and discomfort. When this condition exists, it is frequently mistaken for early and acute hip-joint disease. It will be found on inquiry that the disability followed immediately after the accident. Measurements will show a certain degree of shortening; the trochanter lying at a higher level than normal, and the muscles on guard contracting to protect the injured joint. The x-ray here may be utilized to establish the diagnosis.

Coxa Vara.—In this condition there is sometimes an abnormal curvature of the femoral neck, producing a marked rotation outward, elevation of the trochanter major, and shortening of the limb. The neck of the femur is generally bowed forward, and an unusual degree of rotation outward is often possible, to such an extent in some instances that the patella looks almost directly outward. While certain of these conditions might suggest hip disease, it is soon evident on examination that tuberculous arthritis can be excluded. In these cases there is no history of the earlier manifestations of hip trouble. Then, too, complete extension is usually possible, while the reverse is characteristic of a tuberculous hip. There is an absence of the usual indications of disease in the joint. The less marked cases of coxa vara, where there is limitation of movement in flexion and in abduction, are sometimes mistaken for early hip-joint disease.

Congenital Dislocation of the Hip.—Confusion can hardly occur here if careful examination is made. The lameness from which the child suffers has been present from the time when the child began to walk, and there is an entire absence of the local signs of disease.

Acute Osteomyelitis.—The sudden onset here of acute symptoms, with high fever and the early formation of an acute abscess, is in marked contrast with the usual insidious appearance of tuberculous disease. Acute epiphysitis at the hip runs a very rapid course, with grave constitutional disturbance manifesting itself often after one of the acute infective fevers; the patient is obviously very ill from the beginning of the trouble, and destructive changes proceed rapidly. A recognition of these conditions will prevent confusion with tuberculous disease.

Gonorrhœa and Syphilis.—Gonorrhœal arthritis may simulate hip disease when it occurs in the adult. Here, again, sudden onset is at variance with tuberculous trouble, and the history of the case will throw light upon the condition. In infants, gummatous epiphysitis may occur as a manifestation of congenital syphilis. It is rare, but has been noted as simulating hip disease. Localized swelling is present, and the trouble in the hip is accompanied by other manifestations of syphilis elsewhere in the body.

Scurvy.—Scurvy the pain, tenderness, and swelling about the joints may

simulate hip disease. It is rare, however, that the inflammation is confined to one joint; and when it is so, it is usually the knee rather than the hip. The possibility of scurvy being the cause of joint trouble should, however, be borne in mind, particularly in infants artificially fed.

Rheumatism.—Monarticular rheumatism in the adult or in the young child may occur, but the disease is seldom long confined to one articulation, and thus differs from hip disease. Difficulties in diagnosis may, however, be so marked that it may be impossible to make accurate differentiation between the two conditions. The case may become clear under continued observation, as, for example, through the effect of appropriate remedies in rheumatism. In old patients rheumatism is much more common as a joint affection than tuberculous disease. "Growing pains" in a child are commonly looked upon as of rheumatic origin and the symptoms are not infrequently referred to the hip. These symptoms, however, are, usually very evanescent, and are not likely to be confounded for any length of time with hip disease.

Arthritis Deformans.—In this so-called "rheumatoid arthritis," grating is observed as an early symptom, and irregular ossified outgrowths may occur about the articular ends of the bones. While the hip joint may remain throughout the only joint affected in this disease, yet, as a rule, other joints become involved sooner or later. Old people are the more likely victims, but the disease also occurs in childhood occasionally. The diagnosis is sometimes difficult in the adult, and the x-ray is of service in helping one to determine the true condition present.

Sacro-iliac Disease.—This affection is rare in children; it is quite common in adults. Pain on pressure over the diseased articulation, with absence of pain at the hip, may be determined. Movements at the hip joint may be carried out freely when the pelvis is fixed. Measurements will reveal a normal relation of the trochanter major to Nélaton's line, and other evidences of disease restricted to the hip are absent. Apparent lengthening on the side of the disease is sometimes present. Pain is manifested in a characteristic fashion when the ilia are grasped by the two hands anteriorly and rocked from side to side or pressed together while the patient lies upon the back. The x-ray has proved serviceable in establishing a diagnosis.

Spinal Disease.—The existence of disease in the lower lumbar spine is not infrequently confused with hip disease. The reason is because the pain in this affection is often referred to the lower limb. Further, the muscles attached to and associated with the movements of the spine are the seat of spasm. This involves the psoas muscle, which, by its contraction, may produce flexion at the hip joint to such a degree as to simulate hip disease. The psoas would not, however, cause external rotation, as erroneously stated by some, as the muscle, when in action, is an internal rotator. The psoas contraction in disease of the lumbar spine is usually bilateral, but not always so. Careful examination of

EXPLANATION OF PLATE XXV.

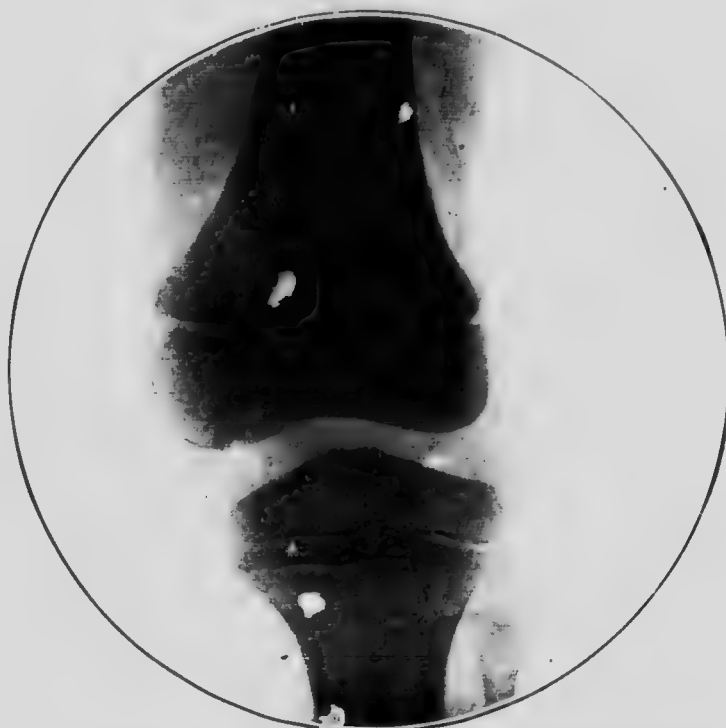
The radiograph illustrates tuberculous disease in the right knee joint. The femur and the fibula are apparently healthy, but the inner part of the epiphysis of the tibia has been destroyed, and a large sequestrum is seen in that locality. The radiograph of the diseased knee (Fig. 4) may be compared with that of the sound side (Fig. 2). The patient was ten years of age and had suffered from trouble in the knee for a year before the x-ray picture was taken. There were marked enlargement of the joint and flexion deformity. The tumefaction had increased very much for a month before the radiograph was made, and an abscess had opened over the inner tuberosity of the tibia. There was marked infiltration of the synovial membrane. At an operation performed upon the joint the accuracy of the conclusions arrived at from the study of the radiograph was confirmed.

The x-ray picture was reproduced by Dr. S. Cummings, of Toronto, under whose care the patient was treated and to whom the author is indebted both for the photographs and for the history of the case.

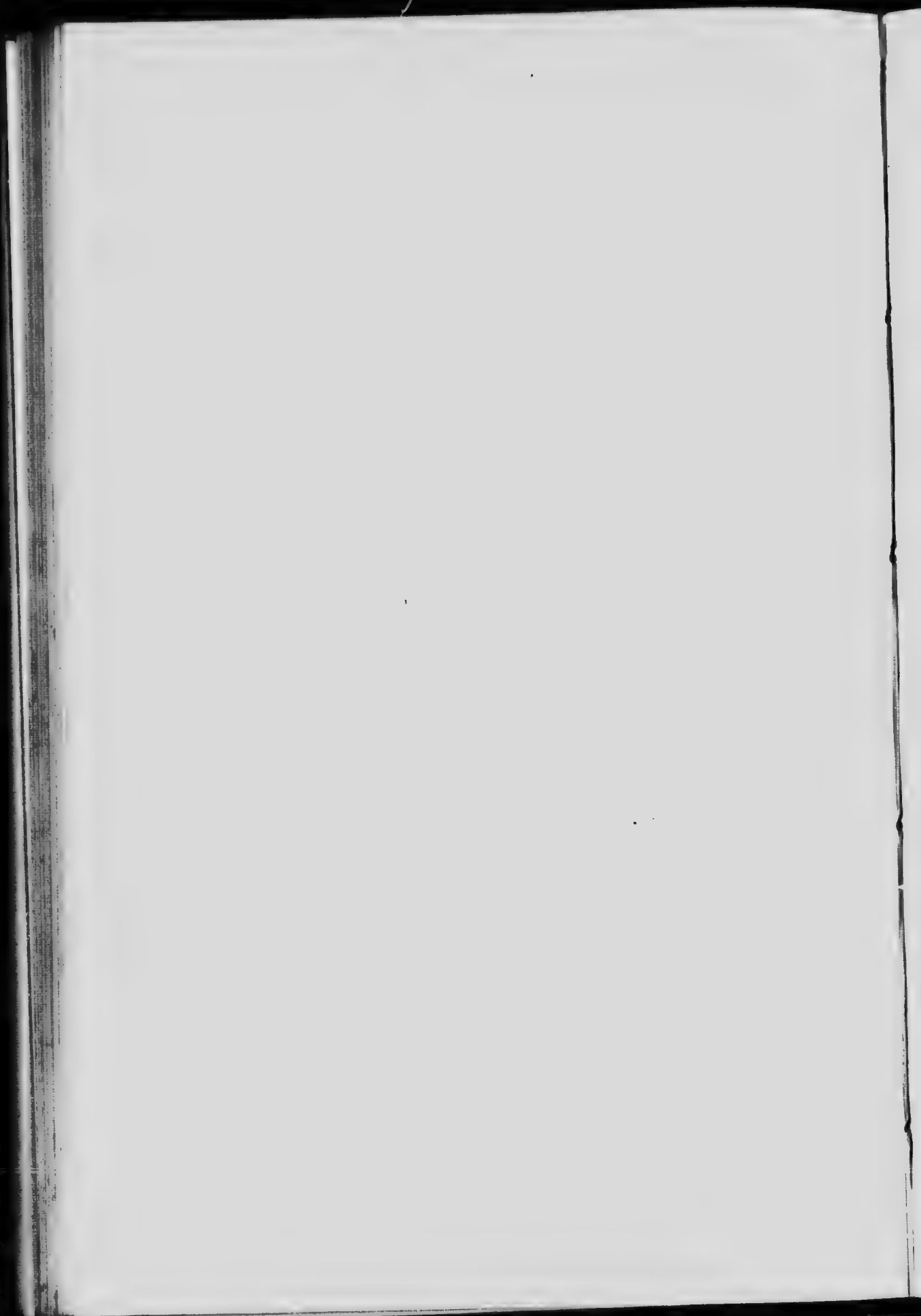
FIG. 1



FIG. 2



RADIOGRAPHS ILLUSTRATING TUBERCULOUS DISEASE IN THE
KNEE-JOINT IN A PATIENT 10 YEARS OF AGE



the hip will enable one to exclude hip disease without much difficulty, but in young children it may be exceedingly difficult to differentiate. If the thigh is flexed on the abdomen so as to relax the psoas muscle, then, in the absence of hip disease, the movements at that joint are unrestricted. This is a very useful method of examination in these cases.

When psoas abscess exists as a result of spinal disease, and when the abscess extends down below Poupart's ligament, we get, on the antero-internal aspect of the thigh, a fluctuating tumor which may be mistaken for an abscess having its origin in the hip. If such an abscess were the result of hip disease we would expect indications of trouble in the hip of a marked character, with elevation of the trochanter major and other evidences of destructive changes in the joint. These, however, are absent in spinal disease.

Affections of Bursæ about the Hip.—The ilio-pectineal or the trochanteric bursa may become inflamed and cause a painful fluctuating swelling in the one case on the anterior aspect of the hip, and in the other posteriorly. Conditions of this kind may be mistaken for abscess connected with hip disease, but careful examination shows that the essential signs of hip disease are wanting.

Tumor.—A new growth such as a sarcoma may involve the tissues about the hip and produce a painful swelling, with limitation of movement. The character of the enlargement and the history of its development will usually be sufficiently characteristic to exclude hip-joint disease.

Sciatica.—An error in diagnosis is not infrequently made in confusing sciatica with hip disease. In the latter, however, the limitation of movement, with muscle spasm, is present. In sciatica pain extends down the back of the thigh and the leg, and tender points may often be detected on pressure along the course of the nerve. Complete flexion at the hip will usually produce much pain in sciatica by stretching the hypersensitive nerve.

Hysteria.—Pain in the hip joint and faulty attitude, with lameness, may occur in a hysterical subject, and hip-joint disease may be simulated. These patients usually present other symptoms of hysteria, and examination of the limb shows that muscular atrophy and muscular spasm are absent. There is also entire absence of shortening or other indications of a destructive lesion of the joint structures.

Infantile Paralysis.—At the onset of this disease there may be pain in the hip, but it is suddenly developed and usually is accompanied by a history of febrile disturbance. When the paralysis develops, as it will do at all events in a few days, the diagnosis is apparent.

Inflamed Lymph Nodes in the Groin.—Such inflamed nodes may produce a painful swelling at the hip, and cause the patient to assume an attitude of flexion while movement at the hip is resisted. These inflamed nodes are, however, easily palpable, and a normal joint is found on examination. Other painful conditions in the region of the hip, or the lower part of the abdomen, may

similarly cause the patient to assume an attitude of flexion at the hip in order to relax the fascia at the groin. For example, appendicitis has been mistaken for hip disease, but an examination locally and the history of the development of the case will enable one to establish an accurate diagnosis.

Complications.—Reference has been made (page 566) to the fact that tuberculous arthritis may supervene in a patient who is already a victim of tuberculous disease elsewhere. Thus hip disease may occur in one who is suffering from pulmonary tuberculosis. The reverse order of events may, however, take place, and the subject of hip disease may develop tuberculosis in some other part of the body; occasionally this fresh development is obviously derived directly from the primary focus of disease in the hip. The most notable instance of this is where tuberculous meningitis manifests itself in hip disease. Occasionally, too, a patient who suffers from a purely localized lesion in the hip becomes a victim of disseminated miliary tuberculosis. These secondary manifestations of tuberculosis have in some cases a direct relation to some suddenly induced activity in an old tuberculous focus which has become quiescent. Thus it appears that the breaking down of adhesions in a joint which has become ankylosed during the progress of disease in the hip may be followed by tuberculous meningitis or disseminated miliary tuberculosis.

A complication the importance of which cannot be exaggerated is that which occurs as the result of mixed infection of an abscess which is primarily a purely tuberculous lesion. The serious and often fatal results which may follow mixed infection are frequently preventable; hence the importance of recognizing this complication of tuberculous arthritis. The appropriate methods of dealing with a tuberculous abscess have been discussed elsewhere, but here we wish simply to narrate the sequence of events which are likely to follow mixed infection. It is usually a staphylococcus infection which supervenes, and, when this occurs, the whole aspect of the case is changed; destructive processes make havoc of the joint structure, and complete disintegration of the articulation may occur. It is, however, continued suppuration which soon produces constitutional effects, and we frequently have a familiar train of symptoms occurring in these cases. General toxæmia is induced, and as a result there is failure of nutrition, with emaciation; visceral disease manifests itself, with amyloid degeneration of the internal organs. Finally, the patient may die of exhaustion. While these results are fortunately not always reached where mixed infection occurs, yet they are sufficiently frequent to put us on our guard and to induce us to exercise the most scrupulous care in using efficient prophylactic measures where they are at all practicable.

There are certain complications which are produced more or less by mechanical means in the course of hip disease of long standing. Thus, there may be permanent changes in the lumbar spine where extreme lordosis has been long maintained, so that permanent deformity may result. Similarly, lateral

EXPLANATION OF PLATE XXVI.

The radiograph illustrates tuberculous disease of the ankle joint and tarsus. It will be seen that the disease has involved the ankle joint and has caused considerable destruction of the lower end of the tibia and of the astragalus. The other bones of the tarsus show a marked condition of rarefying osteitis, the normal architecture of the cancellous tissue is lost and is replaced by a diffuse, somewhat blurred shading, while the surrounding layer of compact tissue shows up as a delicate tracing, as it were pencilled in with clear definition. These characteristic appearances are at once appreciated when one compares the radiograph of the diseased foot (Fig. 1) with that of the sound foot (Fig. 2). The patient was twenty years of age and, about six months before the radiograph was taken, suffered a severe sprain with, probably, rupture of some of the ligaments. The usual signs of tuberculous infection subsequently developed. The foot was amputated, and the accuracy of the conclusions arrived at from a study of the radiograph was confirmed.

The x-ray picture was reproduced by Dr. S. Cummings, of Toronto, under whose care the patient was treated and to whom the author is indebted both for the photographs and for the history of the case.

FIG. 1

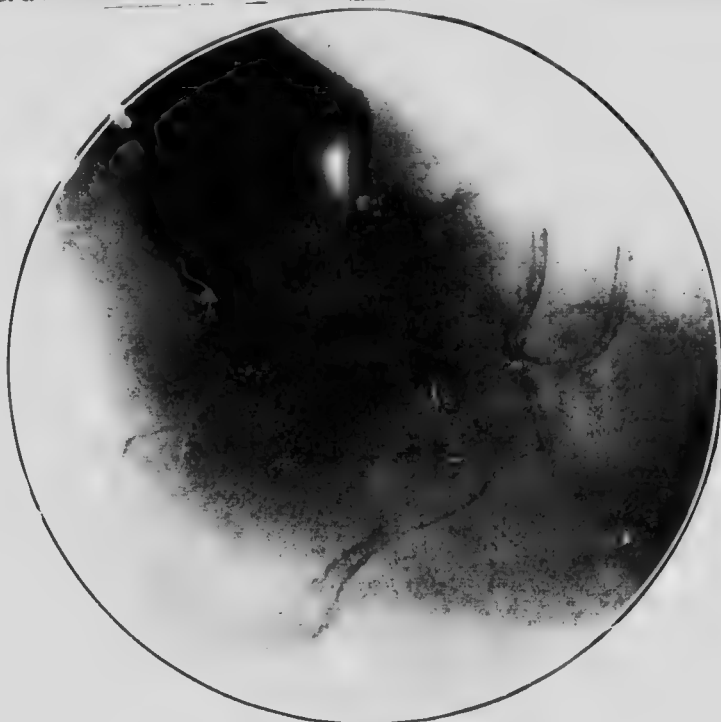


FIG. 2



RADIOGRAPHS ILLUSTRATING TUBERCULOUS DISEASE OF THE
ANKLE-JOINT AND TARSUS IN A PATIENT
20 YEARS OF AGE

curvature after persistent adduction may result in permanent spinal deformity. In the knee, too, long-continued adduction may produce knock-knee. Genu recurvatum results from a laxity of the ligaments about the knee joint, produced apparently by continued rest in the recumbent position. Lastly, talipes equinus may result from permitting the foot to be drooping and unsupported while walking with a splint so constructed as to prevent the weight of the body being transmitted through the diseased limb, while the opposite limb is supported on a boot with a high sole and heel. As a rule, most of these deformities can be prevented by suitable treatment.

Prognosis.—This must be considered from two aspects, namely, with reference to the functional result obtained as far as the joint is concerned, and with reference to the mortality attendant upon the disease. Hip-joint disease is to be considered a serious affection, and the prognosis must be always guarded, as it is impossible to predict the outcome with any degree of positive assertion in the individual case. The disease is a local manifestation of tuberculosis, and as such is classified as a form of "surgical tuberculosis," the course of which is usually favorably influenced by local treatment. The constitutional state of the patient must, however, react upon the local trouble, and so we find that morbus coxae, developing in a sickly infant, is a much more serious matter than when the health is good and the general nutrition well preserved. Similar conditions influence the course of the disease at any age. A strong family history of tuberculosis also has a definite and unfavorable bearing upon the prognosis. These considerations are discussed at length in the earlier part of this article, under the heading of Prognosis in General (page 584). The existence of a tuberculous lesion elsewhere in the body is presumptive of a low power of resistance to the inroads of the bacillus, and the outlook is bad in such cases.

The prognosis is materially affected by the formation of an abscess, and particularly so when mixed infection occurs. In these cases not only is there evidence, in the abscess formation, of destructive processes of an extensive character, but there is at once instituted a menace to the general health as the result of absorption from the infected abscess. Constitutional disturbance occurs with failure of nutrition, the internal organs become diseased, albuminuria is likely to supervene as the result of amyloid disease of the kidneys, and so the case may progress to a fatal termination along such lines. The destructive processes which continue in the joint in these cases will greatly diminish the possibilities of a good functional result should the patient recover.

The *mortality of hip disease* is variously estimated by different observers. The difficulties in producing accurate statistics are great, because of the fact that the cases must be followed for a number of years before a complete cure can be assured. The German surgeons place the mortality in hospital cases higher than do British or American surgeons. Thus, Koenig places the mortality at

40.3 per cent. In the Alexandra Hospital, London, the mortality in 384 cases was 26 per cent. At the Hospital for the Ruptured and Crippled, New York, Gibney reported 288 cases with a mortality of 12.5 per cent; Cheyne, of London, in his series of 77 cases had a mortality of 12 per cent.

The effect of abscess upon the mortality is striking; thus von Bruns, quoted by Whitman, found the mortality in non-suppurative cases to be 23 per cent, as compared with a mortality of 52 per cent in suppurative cases. Another valuable observation is with regard to the mortality in patients treated in private as compared with those treated in hospital clinics. This comparison is made by Whitman in quoting the following statistics: In 94 cases in private reported by Taylor (including 24 cases in which suppuration occurred) there were only 3 deaths. Sayre reported 212 similar cases with 5 deaths, and Lorenz 60 cases with 3 deaths. The logical conclusion is obvious, namely, that careful and efficient treatment has a marked effect on the progress of the disease, and the necessary conditions for securing the best results are difficult to fulfil in hospital practice.

A fatal termination, in hip disease, has been due to one of the following complications:

Tuberculous meningitis.	Tuberculous peritonitis.
Anyloid disease.	Acute miliary tuberculosis.
Exhaustion.	Septicæmia and pyæmia.
Pulmonary tuberculosis.	Shock following operation.
Intercurrent disease.	

When hip-joint disease occurs in the adult the prognosis is worse than in the child, because, as a rule, the disease in the adult runs a more severe and destructive course than is the case in children. In some recent statistics published by Lewiasch from Kocher's clinic in Berne, 100 cases were reported. In 25 of these there was abscess formation with a mortality of 65 per cent. There were 75 cases without abscess, having a mortality of 13.3 per cent. Of those with suppuration 45 per cent of mortality occurred in children, while 80 per cent of mortality occurred in the adults. Of those without suppuration there was a mortality of only 8 per cent in children, and a mortality of 18.2 per cent in the adults.

The functional results obtained in the treatment of hip-joint disease necessarily vary with the extent of the disease and the efficiency of the treatment. When the case comes under observation at an early stage and treatment by rest and immobilization is adopted and efficiently carried out, recovery may take place with little, if any, restriction of movement, and almost perfect function is restored. The other extreme is where destructive processes have gone on to complete disintegration of the joint, resulting in fibrous or bony ankylosis, there being complete absence of mobility.

Efficient treatment is not only of service in restoring the normal function

EXPLANATION OF PLATE XXVII.

The radiograph illustrates tuberculous disease of the wrist. The patient was two years of age. The greater part of the carpus was cartilaginous; ossification had appeared only in two bones of the carpus, namely, the os magnum and the unciform, and in the lower epiphysis of the radius. The x-ray picture showed tuberculous invasion of these two carpal bones and of the proximal extremities of the second and third metacarpal bones. The characteristic appearances are at once appreciated by comparing the radiograph of the diseased wrist (Fig. 1) with that of the sound side (Fig. 2). The patient had exhibited signs of tuberculous affection of the right wrist for three months previous to the making of the x-ray picture. An operation was performed, and the accuracy of the conclusions arrived at from a study of the radiograph was confirmed.

The x-ray picture was reproduced by Dr. S. Cummings, of Toronto, under whose care the patient was treated and to whom the author is indebted both for the photographs and for the history of the case.

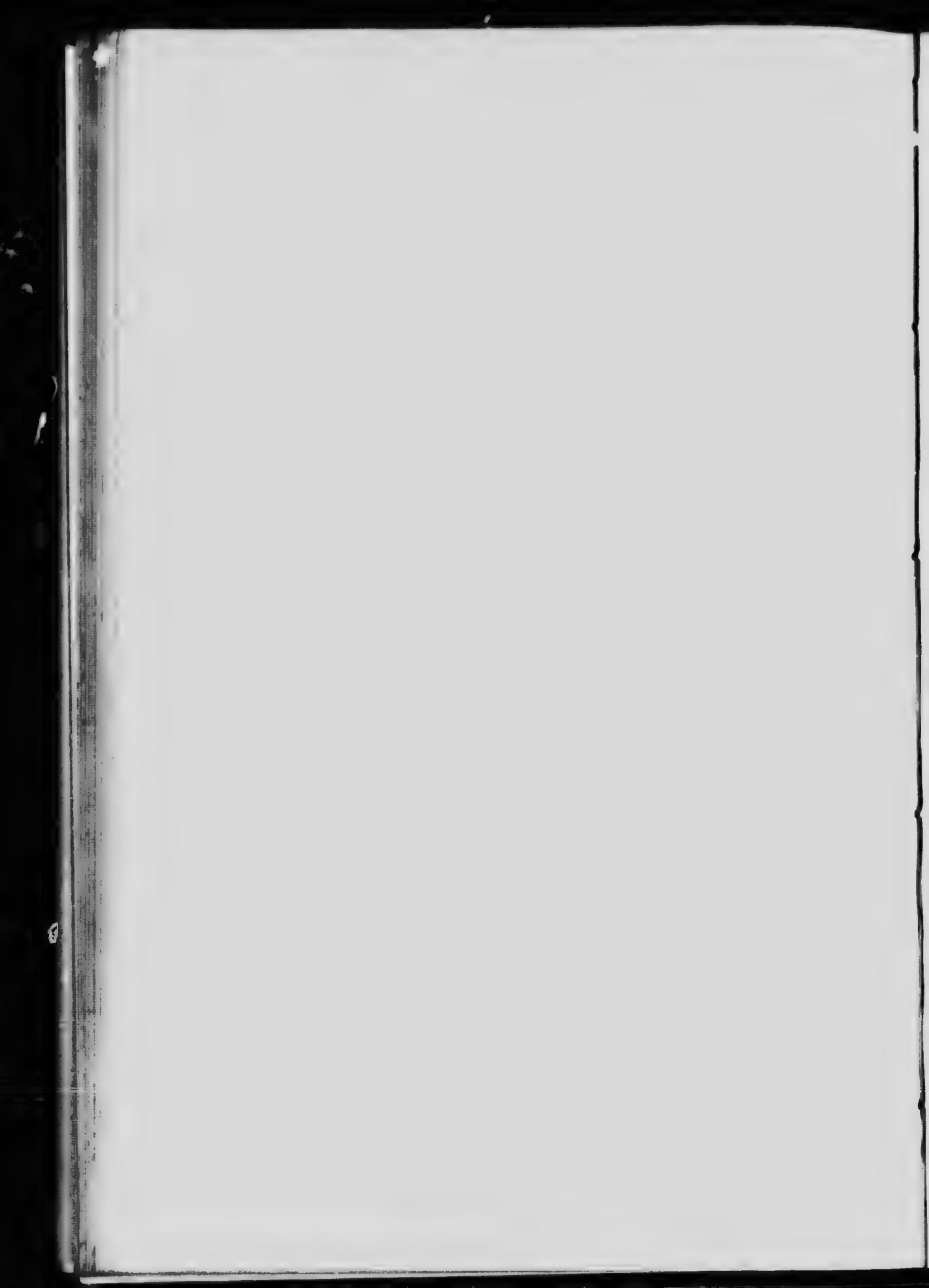
FIG. 1



FIG. 2



RADIOGRAPHS ILLUSTRATING TUBERCULOUS DISEASE OF THE
WRIST-JOINT IN A CHILD TWO YEARS OF AGE



of the joint, as is happily the case in some instances, but, by appropriate means, deformity may be prevented, and, if a stiff joint results, the limb is fixed in a position which will subsequently be of most service to the patient. Shortening is inevitable if there is destruction of bone; flexion and adduction may, however, be corrected or prevented by appropriate mechanical apparatus. If the disease comes under observation at an early stage, then it will be necessary to maintain treatment for at least two or three years before a cure can be assured, even where satisfactory progress is made.

A slight degree of flexion may not cause much disability, but, when it amounts to more than thirty degrees, the impairment of function is marked. In extreme cases the joint may be fixed with flexion amounting to ninety degrees, and then much discomfort and disability results.

Such extreme flexion and too marked adduction often call for operative interference in an old-standing case with an ankylosed joint, but by such means a good functional result may still be obtained, the joint of course remaining stiff, but the deformity being corrected. In this connection it may be noted that much more disability occurs from deformity than from ankylosis.

The shortening which occurs in hip disease is not of itself a cause of great disability. In the absence of other deformity the effects of shortening can be overcome by wearing a boot with a high heel and sole.

In a series of 107 cases quoted by Whitman, as reported by Gibney from the Hospital for Ruptured and Crippled, New York, the following results were obtained: The patients were cured after mechanical and operative treatment. In many cases the disease was in an advanced stage, and deformity was present in more than half the cases when treatment was begun.

No flexion.....	47
Flexion of 10 degrees..	30
Flexion of 10-20 degrees..	20
Flexion of 20-30 degrees..	10
Perfect motion was retained in.....	13
Good motion was retained in.....	22
Limited motion was retained in.....	41
There was ankylosis in.....	31

In 69 cases the shortening was one inch or less, 35 having no shortening. In 38 it was more than one inch.

The amount of shortening which is attained depends largely on the stage at which treatment is initiated. If efficient treatment is adopted early and maintained, there may be little or no shortening. Then, again, it should be noted that the growth and nutrition of the limb may be permanently damaged, so that, even after the disease has become quiescent, there may be an increase in the disparity in length of the two limbs, because the sound limb grows out of proportion to its fellow.

Conservative treatment affords the best prospect for good functional results.

Patients who have been treated by conservative methods recover with a more useful joint than those who have been subjected to operation. This broad statement requires some qualification in view of the fact that the conditions which demand operative interference are such that under any form of treatment marked disability would be the final outcome. The class of cases which we now submit to operation are those in which the lesions have been more than usually destructive to joint structure, and hence the degree of disability resulting must be proportionately greater. While the immediate result of an operation, such as an excision, may be to increase the amount of shortening to a slight extent, the object aimed at in its performance is to improve the local conditions so that a cure may be effected; the final result of operative interference in such cases therefore, if we attain our object, is to bring to an end the destructive processes which are actively progressing and thus minimize the amount of disability which would otherwise occur.

Early operative interference, such as was once advocated strongly, is not now entertained as a rational procedure because the functional result is not satisfactory; in this class of cases undoubtedly the best results are obtained from conservative treatment.

One exception may be made to the argument against early operative interference, and that is in the case of abscess formation, which may occur at any stage of the disease. Occasionally an abscess is best left alone, but at times operation is imperative in order that it may be got rid of before it reaches the surface, when mixed infection threatens. Such cases treated by appropriate measures, which will be described, are much more likely to yield a good functional result than when the abscess is allowed to attain large size and threatens to point upon the surface.

Treatment.—The principles to be observed in the treatment of hip-joint disease are in all essential details similar to those applicable to the treatment of tuberculous arthritis in any part of the body. In tuberculosis of the hip, however, we are seldom able to employ local operative measures for the eradication of limited foci of disease, measures such as are possible in other joints when the clinical signs, aided perhaps by an x-ray photograph, demonstrate a focus confined to a definite portion of the bone. The possibility of removing a focus of disease from the outer portion of the femoral neck will be referred to later, but, with this exception, operations of this nature are inapplicable to the hip; the peculiar structure, relations, and functions of this joint precluding the employment of such operative measures for relief. We are, therefore, forced to employ more conservative methods of treatment; the object aimed at is to secure for the diseased joint the best possible conditions favorable to spontaneous recovery. The satisfactory termination of a case of hip-joint disease depends upon the measure of success we attain in so raising the power of resistance of our patient that a cure of the disease is finally brought about.

Apart from the local measures we must see to it that the general health is improved by appropriate constitutional treatment: the importance of this cannot be overestimated. Satisfactory hygienic surroundings must be secured, the patient must live in the open air as much as possible, his room must be properly and efficiently ventilated, he must get suitable and nutritious food; exercise, so far as the conditions will permit, must not be overlooked. Certain remedies, such as cod-liver oil, the hypophosphites, arsenic, and the syrup of the iodide of iron are found useful in individual cases. The constitutional treatment has been discussed at length in the treatment of tuberculous joints in general (page 586), and a more extended reference is unnecessary here.

The so-called conservative treatment, if efficiently carried out, will do much to lessen the duration of the disease and to prevent the deformity and loss of function that invariably result in cases that have progressed and have been left untreated.

In untreated cases the time that must elapse before a natural cure is established is usually six or seven years, and at the end of that time the limb is in a position of marked flexion and adduction, with shortening to the extent of several inches as a consequence of tilting of the pelvis and the actual upward displacement of the femur, with destruction of the articular extremity to a greater or less degree. It may be considered fortunate, in fact, if the result in such untreated cases should prove as good as that just described. Very often the disease progresses to a still more unfavorable termination: in many instances, for example, the long-continued suppuration, common in neglected hip disease, induces amyloid degeneration in the viscera, and matters go from bad to worse until a fatal issue is inevitable. Efficient treatment in such cases as these would have shortened the duration of the disease by three or four years and probably suppuration would never have occurred, deformity would have been prevented, and the suffering which always accompanies the disease would have been lessened to a marked degree.

Too much stress cannot be laid upon the importance of an early diagnosis, for upon the stage in the progress of the disease at which efficient treatment is instituted depends the degree of success we attain in securing a good functional result. If the condition is recognized when the trouble is still confined to the bone, one may hope for a more or less complete restoration of the movement at the joint. But if the joint cavity has become involved with well-established erosion of the cartilages, the best result that one can hope for, by efficient treatment instituted at this stage, is ankylosis to a greater or less degree without deformity and with a minimum amount of shortening. If treatment has been delayed until actual upward displacement of the femur has taken place as the result of the absorption of bone or of a pathological dislocation, or until ankylosis in a deformed attitude has occurred, the best that can be done is to adopt measures that will lead to the eradication of what remains

of the disease as soon as possible, and then by operative procedure to correct or lessen the deformity.

The indications for treatment, therefore, depend upon the stage in the disease at which the case is first seen. In the acute stage one must relieve pain, prevent and correct deformity, and combat the tendency to shortening from erosion of cartilages and bone, and the greatest care must be taken to prevent the onset of suppuration.

The most efficient treatment is that which provides the most complete rest and protection for the affected joint. Obviously this can best be obtained when the patient is kept in the recumbent attitude. But when it is found that the pain has disappeared and the muscular spasm and the other local signs have pretty well subsided, it then is wiser to get the patient up, provided, of course, the surgeon has the means of securing ambulatory apparatus which will in an efficient manner secure the rest which is necessary for the joint while the patient goes about. The ambulatory treatment always has the advantage that the patient gets more exercise and more fresh air than when he is kept constantly in bed, and consequently the general health is much more likely to improve.

To provide rest for the diseased joint we have, along with recumbency, two very effective measures at our command, namely, splinting and traction.

The object of splinting is to prevent motion at the joint and so to guard the diseased cartilages and synovial membranes from injury that muscular spasm, now no longer necessary for protective purposes, will tend to disappear. The fixation of the affected part, too, will so protect the sensitive joint that the greater part of the irritation of the nerve endings in the joint will cease, and hence the reflex muscular spasm will be abolished. Theoretically, if we could produce perfect fixation this treatment would be all that is required, but as this is practically impossible the method sometimes fails.

Traction is a valuable adjunct to the treatment in that, by its proper use, muscular spasm can be frequently controlled. If a patient in the acute stage of the disease be put to bed with traction of about five or six pounds, gradually increased to ten or twelve pounds, the muscles soon become tired and the spasm is overcome. By this means the pain, which is due to the pressing of sensitive articular surfaces together as the result of contraction of the muscles, is prevented, and the faulty attitude which results from muscular spasm disappears. Examination of specimens of diseased hips, post mortem, shows that erosion of the cartilages takes place most extensively at the points of contact of the femur and acetabulum. Consequently, in cases where active disease is going on it is wise to lessen the pressure between the joint surfaces by traction and thus try to limit the amount of actual shortening which will result from destruction of bone and cartilage. In a series of experiments on healthy children Bradford and Lovett demonstrated that actual "distraction" of the joint

is possible under a steady pull of twenty pounds, and in diseased joints the amount of traction required diminishes with the amount of disorganization present.

Traction is made upon the limb by means of adhesive strapping, either of the moleskin or of the zine-oxide variety, applied to each side of the limb, from the upper part of the thigh to below the knee. The strapping is cut into strips so that it will lie smoothly on the surface of the skin and in order that areas of skin may be left uncovered which may be used when the strapping is changed (see Fig. 268). At the lower end of each strap is a buckle into which fits the strap of a metal crosspiece which serves to spread the traction straps sufficiently to prevent injurious pressure on the malleoli. When the strapping has been applied, it should be covered with a cotton or flannelette bandage from the toes



FIG. 268.—The Method of Applying Traction Plaster to the Limb (Original.)

to the groin and this bandage should be further secured by the application of stitches to the margins to prevent its being disarranged. To apply an extension apparatus in an acute case, the surgeon requires an assistant, who exerts gentle traction on the limb by grasping the heel and pulling in the line of the axis of the limb. Care must be taken to handle the limb gently in the application of the plaster and bandages. A point to be remembered is that the strapping must be applied high upon the thigh and not very far down on the leg, the reason being that if the plaster be mostly fixed to the leg, the traction on the hip is transmitted through the knee joint, and long-continued strain upon the supporting ligaments of the knee results in weakening and relaxation of that joint. When the strapping and adhesive bands have been satisfactorily applied, a rope, which runs over a pulley at the foot of the bed and to which is

attached the weight decided upon, is fastened to the metal crosspiece. To prevent the patient from being drawn down in the bed by the constant traction, counter-traction is provided by raising the foot of the bed or by passing beneath the perineum a padded band which is attached to the top of the bed.



FIG. 269. The Long Plaster Spica used in the Treatment of Hip-joint Disease. (Original.)

Splinting may be provided by the use of a long plaster spica, extending from the mammary line down to and including the foot (see Fig. 269).

The most efficient treatment for acute disease is that which employs both splinting and traction. Frequently it is found that cases which do not respond to either method when used alone, are easily controlled when they are used together. By this means we have the benefit of both fixation and traction in relieving muscular spasm, the joint is protected from sudden motion by the splint, and the tendency to upward displacement from destruction of the cartilages and absorption of the bone is lessened by the traction.

The best manner of obtaining this valuable combination is by means of the plaster spica, put on over an ordinary adhesive-plaster extension applied to the thigh. After the adhesive plaster and bandages have been applied to the leg and thigh, the upper

part of the thigh and the body are covered with seamless shirting or stockinette. The patient is now elevated upon a pelvic rest of the type shown in the photograph (Fig. 270), and, after the pelvic bones, the spine, and the front of the chest have been protected with one layer of silence cloth, a plaster spica is applied, extending from the ankle to the mammary line. Care must be taken to strengthen the plaster at the groin, as this is the part that is under the greatest strain. This may be done by making the plaster thicker at this point or by incorporating strips of basswood or even steel. An important point to be observed is to see that the buttock is completely covered in, only sufficient room being left between the edge of the plaster and the cleft

of the nates to prevent soiling of the plaster. This may be accomplished by making a small pad of plaster, about seven inches by five inches and about ten layers in thickness, and fastening it over the buttock by several turns of the bandage. The reason for this procedure is the necessity of providing a good posterior support and protection for the joint, and also of preventing the excoriation of the buttock that invariably takes place if the edge of the plaster is left opposite the gluteal fold, thus allowing the buttock to bulge out of the spica. When the spica is dry it should be covered with stockinette, which may

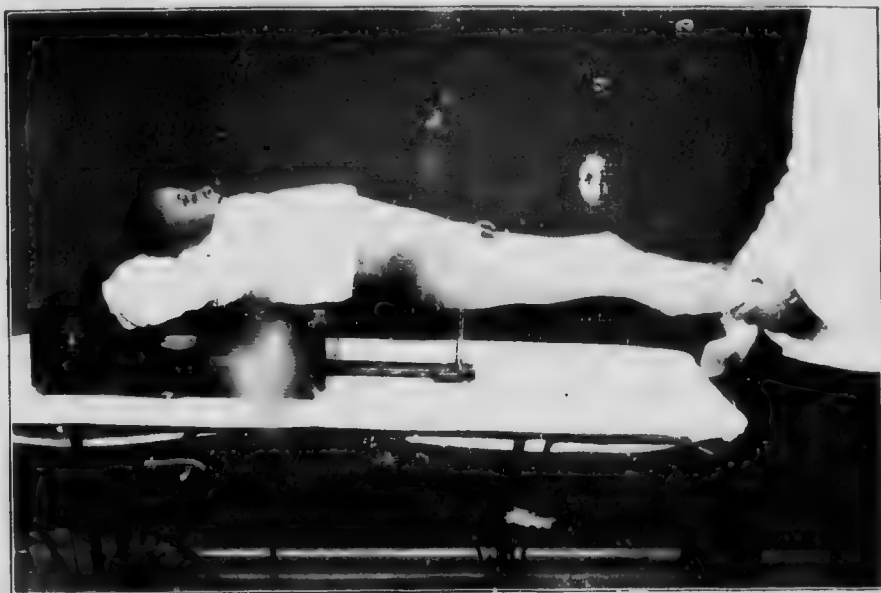


FIG. 270. Pelvic Rest and Back Rest Employed for the Application of a Plaster Spica. A flat steel plate is applied to the sacrum at the end of the upright shown in the picture. The back rest here consists of a suit case into which the sacral support is allowed to slide on a horizontal bar. The case may be suitably furnished with plaster bandages, etc., and forms a convenient portable outfit for plaster work. The apparatus was devised by Dr. W. E. Gallie, of Toronto.

be changed in case it becomes soiled. In dealing with very small children, however, it is sometimes better to protect the area about the perineum with oiled muslin or by varnishing the plaster, in which case it may be washed. When the patient is put to bed, a weight of from five to fifteen pounds is applied. Within a few days the plaster in becoming dry loosens somewhat, and, later on, the leg shrinks a little; hence the importance of the traction is manifest. The traction is also of service in preventing the upward displacement of the spica. The grip that the plaster obtains on the bony points of the pelvis is never sufficient to oppose any considerable force exerted in an upward or downward direction, but it has sufficient grip upon the thigh and leg to be drawn down by the traction.

The above is the treatment advised for the very acute cases where night cries are frequent and pain severe. In cases, however, in which the symptoms are not so severe, less stringent measures are applicable. In these cases it is not necessary to fix the body above the pelvis: it is sufficient if the plaster extends from the ankle or from the knee to just above the crests of the ilia. In children who are not too fat and whose crests are fairly prominent, a most efficient spica may be applied in this manner, as is shown in the photograph (Fig. 271). This type of spica, commonly known as the short or Lorenz spica, has the advantage that it allows free movement of the spine while retaining nearly perfect fixation. As there is sometimes a tendency, on the part of the spica on the well side, to slip upward, it is customary to incorporate two



FIG. 271.—Short Plaster Spica Permitting Flexion at the Knee Joint. (Original.)

buckles fastened to pieces of perforated tin in the back and front of the plaster, and to attach to them a perineal bar.¹ By this device all tendency to adduction deformity is prevented.

For the less acute cases it is the custom in some hospitals to use traction alone, and, when the patient is in the hands of a competent nurse, the rest to the joint thus produced is fairly efficient. To prevent the flexion which occurs as a result of the sagging of the pelvis into the soft bed, the patient is made to lie on a hard, flat surface, the Bradford frame being the most convenient (see Fig. 272). To maintain a perfectly horizontal position and to produce a little fixation, a tie-down of the type shown in the figure may be used. The disadvantages of this treatment, however, are manifest, as in the majority of cases the patient moves about, and, in the daily changing of the sheets and using of the bed-pan, disturbance of the hip is unavoidable. It is the custom at the Hospital for Sick Children, Toronto, to put these less acute cases into a bed splint which was devised by Dr. W. E. Gallie and which is shown in the photographs (Figs. 273 and 274). It consists of a long outside bar of three-eighths-inch steel which is heavy enough to hold the hip and light enough to be bent to the attitude

of the limb. On it are three padded steel bands which encircle the chest, pelvis, and knee, and lower down there is a cup to support the ankle. These bands are sufficiently light to be bent to fit different-sized children, and by use of the thumb-screw, which fastens the bands to the bar, the splint is made adjustable in length also. A nice modification of this is to make a leather back for the splint, made by moulding it over a cast of the patient's back. The device at the bottom of the splint is for the purpose of retaining the traction undisturbed when the patient is moved about. The rope which connects the adhesive extension with the weight and pulley runs through a hole in the bottom of the splint, into which fits a clamp which can at any time be screwed down to catch the rope firmly. With perineal bands acting as counter-traction the limb is thus held firmly while the patient is lifted about or while a dressing is being done. One great advantage of this splint is that, by bending a portion of the longitudinal bar into a U, one can do a dressing in the region of the hip without removing the splint and without disturbing the limb. After the patient is put back to bed the weight is once more attached. Another device much used is the Thomas hip splint (Fig. 275). It consists of a posterior bar of light iron which is made to conform to the curves of the body, and to which are attached bands for the chest, thigh, and ankle, of sufficient lightness to be easily bent to fit the patient. The advantage to be claimed for this splint is that it can be made by any blacksmith, and, if necessary, by the surgeon himself. It is particularly useful where no orthopedic mechanics are available. A good modification of this splint is the one to which a pelvic band has been



FIG. 272. The Bradford Frame and "Tie-down." It consists of a steel frame to which is laced a canvas support for the patient. The "tie-down" consists of a piece of flattened steel which is fastened to the frame at the sides and at the top. The horizontal piece of this tie-down lies in the concavity of the patient's neck. To this, in turn, is attached by means of straps, a piece of canvas which passes across the patient's chest, and by the means, combined with traction by strips of adhesive plaster applied to the limbs, the patient is effectually secured to the frame in a recumbent position.

added. This provides more perfect fixation to the joint. Traction of course can be used in conjunction with this splint.

Faulty Attitude due to Muscular Spasm.—In practically all cases of hip disease the question of how to deal with the early deformity arises. In even the very mild cases there is usually a slight amount of flexion, and in the severe cases this flexion may reach a right angle with considerable adduction and external or internal rotation. The primary cause of the faulty attitude is muscular spasm, the stronger group of muscles largely determining the attitude of the limb. If, however, the attitude of deformity is maintained for

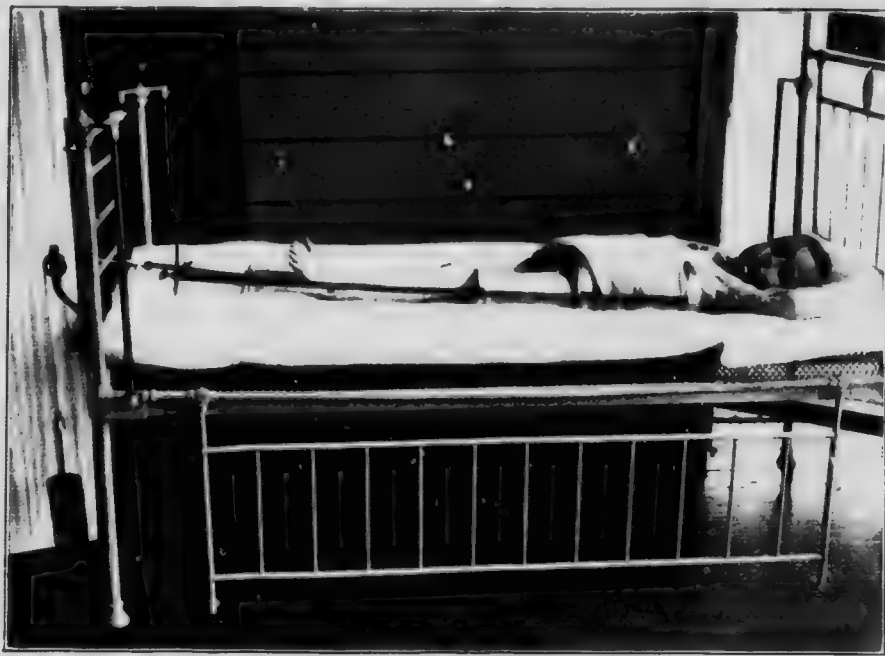


FIG. 273.—Bed Splint Devised by Dr. W. E. Gallie, of Toronto, for the Treatment of the Less Acute Cases of Tuberculous Hip Disease. (Original.)

several months, permanent contracture takes place in the muscle, the ligaments become shortened, and the inflammation about the joint causes the formation of adhesions. As a result it is necessary to apply considerable force in the form of leverage to reduce the deformity.

The treatment therefore devolves itself into two kinds—that which overcomes muscular spasm, and that which reduces the more fixed deformity.

Traction and splinting can both be used, and to advantage, in dealing with muscular spasm. If the former is to be employed, fairly efficient fixation can be obtained by fastening the patient's chest, pelvis, and leg to a steel frame of the type shown in the photographs (Figs. 276 and 277). It will be noticed that the leg is elevated until the lumbar spine lies flat upon the bed. The reason

for this is easily seen when the manner in which the psoas muscle is attached to the spine and trochanter minor is remembered. If the traction were applied in a line parallel with the bed, the thigh would be converted into a lever with the fulcrum at the trochanter minor, and the short arm between the trochanter and the joint. As a result the head of the bone would be forced more tightly into the acetabulum and the muscular spasm correspondingly increased. On the other hand, if the traction be applied in the line of the deformity, with the spine flat upon the bed, the leverage action is prevented and the traction simply expends itself in tiring the muscles and thus relieving the spasm. The

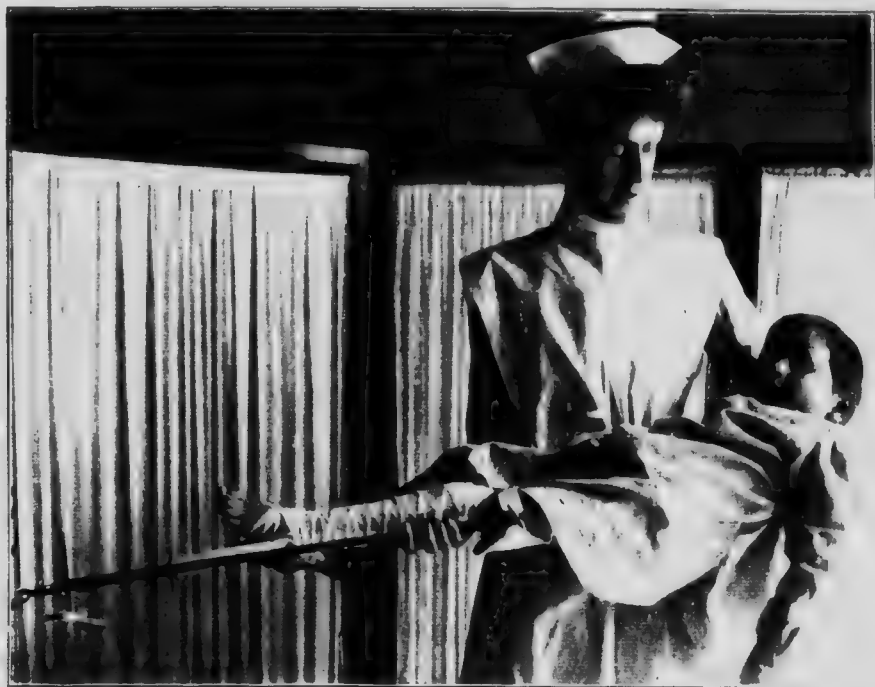


FIG. 274.—Gallie's Bed Splint for the Less Acute Cases of Tuberculous Hip. The illustration shows how the patient may be moved without disturbing the fixation and while extension is still maintained. (Original.)

ilio-femoral ligament may act very much as the psoas muscle in this particular. The neck of the femur in that case forms the short arm of the lever, and the fulcrum is at the point of attachment of the ligament to the anterior intertrochanteric line. Traction in the line of deformity produces much the same effect upon the ligament as upon the muscle; it is gradually stretched, and yields eventually to such an extent as to permit the flexion to be overcome.

The usual procedure is to put the patient into the traction frame which lies on top of an ordinary Bradford frame, and traction of about five pounds is then applied in the line of deformity. The weight is increased a pound a day for

a few days or a week, and then the leg is let down half an inch or so, until the lumbar spine just commences to rise. A few more days are allowed to pass and the same procedure is repeated. If the case is a suitable one for this form

of treatment, all the deformity should be reduced in from two to three weeks.

If muscular spasm is to be combated by the employment of splinting alone, we again have recourse to the plaster spica. The patient is placed on the pelvic rest, with the thigh in the attitude of flexion. A spica is then applied, extending from the toes to the mammary line. In consequence of the fact that the thigh is necessarily flexed at the hip, one must see that the knee is also flexed so that the dorsal spine, the lumbar spine, the sacrum, and the heel of the affected side may be in the same horizontal plane. By this precaution we balance the patient properly in bed and obviate the necessity of any great degree of elevation of the bedclothes. After six or eight weeks have passed, this spica is removed, and in many cases it will be found that the deformity has already become considerably diminished. The explanation of this phenomenon is that, as the deformity is the result of muscular spasm, by removing the cause for muscular spasm by the complete fixation of the joint we have removed the agent which produces the deformity and consequently it disappears.

The fixation treatment is the better method to employ in the more acute cases where pain and night cries are prominent symptoms. The traction method is very useful where the disease is subacute.

A great many cases will be seen where the deformity does not respond completely to either form of treatment. Often the deformity will partially subside, and then,



FIG. 275. The Thomas Hip Splint with Pelvic Band. It is fully described in the text.

apart entirely from acute muscular spasm, show no tendency to be further corrected. These are the cases in which the faulty attitude has continued

for so long a time that muscular contractions, shortening of ligaments, and adhesions have occurred, and consequently no moderate amount of traction or fixation can affect them. The treatment in these cases is to give



FIG. 276.—Traction Frame for the Application of Extension in the Line of the Deformity in Tuberculous Hip-joint Disease. The frame is shown in use in Fig. 277.

an anæsthetic, and, while an assistant holds the lumbar spine flat upon the table by flexing the sound thigh firmly upon the abdomen, forcibly to

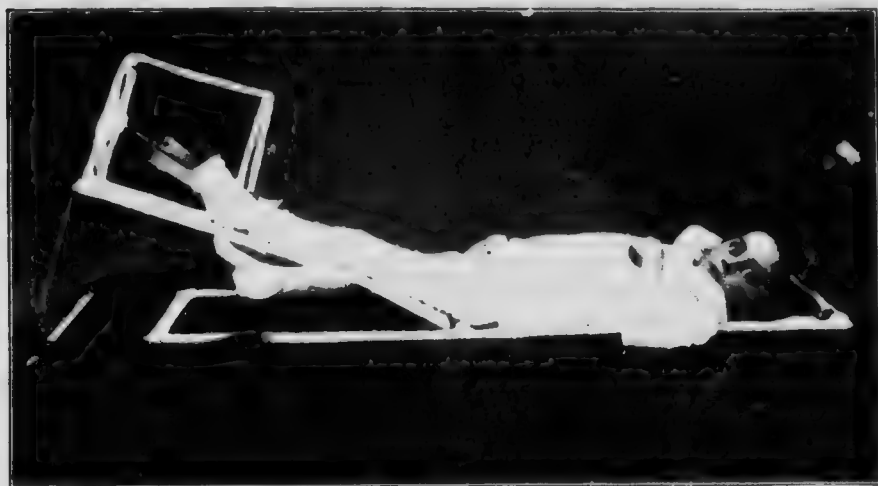


FIG. 277.—Traction Frame Devised for the Purpose of Supporting the Limb and Applying Extension in the Line of the Deformity in Tuberculous Hip-joint Disease. (Original)

reduce the deformity by a pump-handle leverage action. It is wise to draw the patient to the end of the table in order that the flexion can be over-corrected

and that there may be no elastic tendency to recurrence when the fixation apparatus is applied. Care must be taken in this procedure that the force applied does not produce a fracture of the neck of the femur, which is a possibility if due caution be not observed. At the same time the adduction and external or internal rotation should be corrected, the limb being put up with the foot and knee directed but slightly outward and the thigh in moderate abduction. The maintenance of abduction is of great importance, as this is the attitude which causes apparent lengthening and consequently neutralizes any actual shortening that may have occurred. Also, this is the attitude in which it is most difficult for a pathological dislocation to occur, owing to the conformation of the acetabulum and the neck of the femur and the obliquity of the side of the pelvis. It will be seen from the diagram (C, Fig. 257) that when the thigh is abducted the pelvis is tilted downward on that side, and consequently the angle which the line of force directed up the femur makes with the side of the pelvis is less acute than normal, and as a result the tendency of the head of the bone to slide up the side of the pelvis is diminished. In the case of the adduction deformity the angle in question becomes more acute. Consequently force directed up the femur would have a much greater tendency

to displace the head upward by producing the characteristic wandering of the acetabulum or a pathological dislocation. When the deformity has been reduced, either a long spica or a short spica with traction may be applied, the latter being probably the more comfortable of the two.

Following this method of procedure there is seldom much pain if care has been taken to overcorrect the deformity before applying the spica in an attitude which is not overcorrected; usually the temperature rises to 99° or 100° F. for a day or two, but no injurious symptoms in the vast majority of cases have been observed to arise from the procedure. In very rare instances untoward results (tuberculous meningitis) have followed forcible correction of deformity, and therefore it would be wise to reserve this treatment for cases in which there are no symptoms of active disease.

Following the reduction of the deformity the treatment depends upon the severity of the symptoms. If the case is a mild one without much pain, and if the muscular spasm has been largely overcome, the patient may be allowed up in some ambulatory apparatus at once. If, however, the muscular spasm is marked and motion absent, and if there is much tenderness or pain, the patient must be kept in the recumbent attitude, the treatment as outlined above being carried out. In such cases, where the recumbency is likely to be prolonged, it is a good scheme to provide a three-wheeled cart, commonly known in the hospital as a banana cart, upon which the patient may lie instead of being continuously in bed. The cart is about five feet long and eighteen inches wide and is provided with a mattress like that of an ordinary bed. Two large wheels are placed a little behind the middle and a small swivel wheel in front.

By this arrangement the patient can reach the large wheels without rising from the bed, and can move himself about the room at will. This has a great advantage in that it provides exercise that is not injurious and change of scene that relieves the monotony of the treatment.

The question of when to change the recumbent to the ambulatory form of treatment is of the greatest importance. The signs of local acute disease must have markedly subsided, and the patient should have made a substantial gain in general health, before he is allowed to move about. In the very acute cases it is wise to leave him in the recumbent attitude for several months, after the acuteness has begun to subside, in order that the process of repair may be well commenced before any possible strain is applied to the joint. The time in bed may therefore be only a few weeks, or it may be months or even a year, depending on the progress of the case.

Ambulatory Treatment.—In order that ambulatory treatment may be efficient the joint must be provided with nearly as complete rest as when the patient is in bed. In order to accomplish this the joint must be fixed in the proper attitude and the function of weight-bearing eliminated. Some years ago it was claimed by Taylor, Sayre, and other American writers that motion without friction at the hip joint was beneficial. This idea has very few supporters at the present day, the good results obtained by this treatment being attributed to the stilting and partial fixation that their ambulatory apparatus provided. Certain German writers and also some American authorities go to the other extreme and pin their faith entirely on the fixation of the joint, allowing their patients to go about without any provision for the relief of weight-bearing. This has even less to recommend it than the old idea, as the injury caused by the grinding of the diseased articular surfaces together in walking is very considerable. Besides stirring up the disease to renewed activity, this method also is a direct cause of upward displacement of the femur which can by other means be avoided. At the present day the majority of surgeons combine the principles of stilting and fixation, and in looking for an ambulatory apparatus we must choose the one which accomplishes these two objects most efficiently.

The apparatus most commonly used is the long hip brace shown in the photograph (Fig. 278). It consists primarily of an outside bar extending from the mammary line to below the foot. This bar may be solid or spliced, so that it may be extended as the child grows taller. It is quite common also to make the outside bar tubular in form, as suggested by Taylor, and to provide for the extension of the brace by a ratchet and key. To the outside bar are attached three transverse steel bands, for the chest, pelvis, and thigh. At the bottom the outside bar is turned inward at a right angle two and one-half inches to three inches below the foot, and the foot-piece thus formed is shod with sole leather. The transverse bands are well padded and covered with leather or plush. The

pelvic band is provided with four buckles, two close together in front, and two well separated behind. To these are attached perineal bands which, passing under the perineum, support the body weight in walking. These bands are made of strong tape, well padded, and covered with chamois leather. At the



FIG. 278. —The Long Hip Brace used in the Ambulatory Treatment of Tuberculous Hip-joint Disease. (Original.)

foot of the brace are attached three straps, one behind and one on either side. When the brace is applied the posterior strap is fastened into a buckle which is riveted to the heel of the boot, and the side straps are fastened to the buckles on the ends of the adhesive-plaster extensions described above. These latter straps were originally intended to produce traction upon the limb, but the difficulty of keeping the brace accurately adjusted makes this practically impossible. They serve a useful purpose, however, in steadying the limb and thus assisting in its fixation. The heel strap when tight draws the heel down and lifts the toes up, thus providing against the patient touching the foot to the ground and bearing the body weight.

The splint being two and one-half inches or three inches longer than the leg, we must raise the healthy side a corresponding distance. This is done by placing two and one-half inches or three inches of cork between the outer and inner soles of the boot. Cork is the best material, as it is both strong and light. A metal patten may be used if an orthopedic shoemaker is not available. The splint is applied over a soft undershirt, the perineal straps and transverse bands are tightened, the traction and heel straps are made taut, and the patient is ready to walk. At

first he will find it difficult, but within a few days he ought to be getting about without assistance.

When a patient leaves the hospital, wearing a long splint, a list of instructions is given to the parents in order that efficiency may be maintained in the treatment. The brace must be worn night and day, only being removed by the surgeon or the nurse. Care must be taken to see that the perineal straps do not cause excoriations. It is wise to rub the parts with alcohol daily and to apply some drying powder. Every three or four weeks the adhesive

extension must be changed, care being taken to avoid putting the new plaster over skin which had been covered before. By this precaution sores are prevented.

There are several hip splints, the efficacy of which depends on the same principles as the above, but which differ in some of the mechanical details. One is the Phelps hip splint, which, instead of having perineal straps, has a padded steel ring attached to the outside bar and so adjusted that it fits snugly about the thigh and supports the body weight in the perineum. This device has the advantage that it prevents antero-posterior motion, unlike the ordinary chamois straps, and it also cannot be tampered with by the patient or his parents. It has the disadvantage that it is difficult of adjustment and in the case of small children is liable to be soiled.

It will be observed that the treatment of hip disease by apparatus such as the above is in reality a combination of the old Taylor and Thomas methods of treatment.

The Taylor brace was similar to the above, except that the outer bar did not extend above the pelvic band, the thoracic band being absent. The brace depended for its efficiency upon the fact that it stilted the patient and that it attempted to provide constant traction upon the limb. Unfortunately, it did not provide against motion at the joint, and in consequence the deformity of flexion and adduction frequently developed. The fact also that during its employment there often occurred acute exacerbations which were immediately relieved by fixation of the joint in a spica or a Thomas hip splint, was suggestive that an apparatus which should effectively splint the joint would provide the more efficient treatment. As a consequence, the old Taylor brace is seldom seen nowadays in the treatment of acute disease.

The Thomas splint has been described above. When it is used in the ambulatory treatment a sling is attached to the top of the splint and passed over the shoulder to prevent its slipping down (see Figs. 279 and 280). A high boot is placed on the opposite foot, and the patient gets about with the aid of axillary crutches, obviously swinging the foot of the affected side free of the ground. The great



FIG. 279. The Thomas Splint applied in the Ambulatory Treatment of Hip-joint Disease. (Front view).

disadvantage of this, of course, is that in many cases the children will not use the crutches, and are found running about in a lop-sided fashion, bearing the full body weight on the diseased limb.

The advantage of the combination of the two ideas is at once evident, as the good points of each—the stilting of the Taylor brace and the fixation of the Thomas splint—are both employed.

The disadvantages of the long splint are not a few, however. The splint in extending up to the mammary line prevents free motion of the spine. As a result the patient is unable to sit down properly and sometimes complains of discomfort on this account. Again, the appliance, to be effective, requires

constant supervision to see that the bands—perineal and traction straps—are always correctly adjusted. Finally, even with ordinary care, the splint never perfectly fixes the joint, and flexion and adduction sometimes develop.

In the great majority of cases, however, the brace will be found to be entirely satisfactory, and the good results which have been obtained from its extensive employment in the hospitals and dispensaries of America is a good guarantee of its efficiency.

In order to obviate the objections offered to the use of the long hip splint, Whitman, of New York, has recently advocated a combination of the plaster spica and a small stilt-ing brace. Fig. 281 shows this apparatus applied, but without the traction straps. These straps may be omitted in the less acute cases. A Lorenz spica is applied, care being taken to fit it snugly about the crests of the ilia, and provision being made against adduction by incorporating

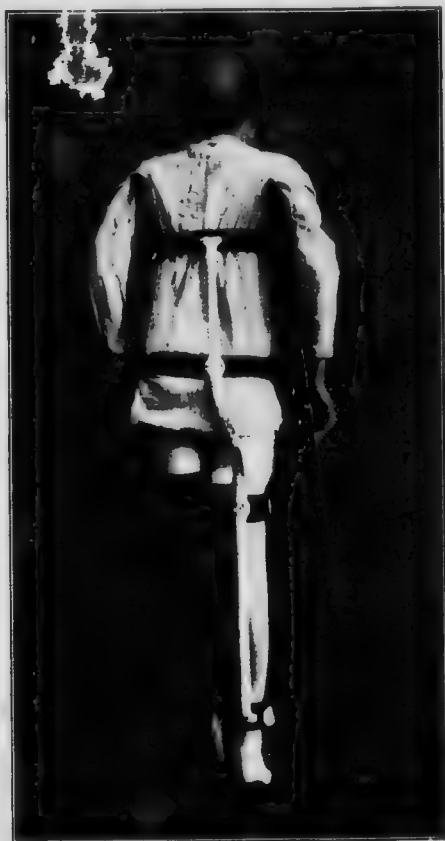


FIG. 280.—The Thomas Splint Applied in Ambulatory Treatment of Hip-joint Disease. (Back view.)

buckles in the plaster for a perineal strap, as described above. The spica is applied over the ordinary traction plasters. Over the spica is loosely fitted a crutch brace of the type shown in the photograph. It consists of an outside bar terminating below in the ordinary foot-piece, which is provided with the

three straps in exactly the same manner as is the long brace described above; the bar ends opposite the hip joint and is attached to a transverse steel band which extends anteriorly and posteriorly sufficiently far to support buckles for the attachment of a single perineal strap. Usually the part of this transverse band behind the vertical bar is bent upward a little to fit the plaster and to escape the uncovered buttock. Just above the knee is a transverse band which holds the brace against the thigh. The whole brace is loosely applied, so that when the patient places his foot on the foot-piece the body weight will not be transmitted through the thigh to the brace, but will be entirely supported by the perineal band, no weight being transmitted through the plaster spica.

By this scheme we have almost perfect fixation of the joint, combined with efficient stiltting. The spine, being unencumbered, is allowed free movement, and the patient is enabled to sit up in a chair without difficulty. The spica prevents the possibility of injury to the joint, whereas such injury may occur where there is neglect in looking after a brace. The device has also the advantage that it is light, the spica weighing little over a pound, and the small brace containing the minimum amount of steel.

This method has been employed in the Hospital for Sick Children, Toronto, and has given complete satisfaction. It has been found that, owing to the efficiency with which it provides rest to the joint, recumbency may be abandoned much earlier than otherwise, and sometimes may be dispensed with altogether. The difficulty, of course, is in the application of the spica, which requires care to make it efficient. In addition to this form of treatment it is suggested that the traction straps should be unbuckled at night or that the entire brace should be removed and a weight attached to create traction during sleep. The weight may be attached to the foot-piece of the brace while the traction straps are still attached to it, and the same result may be thus accomplished.

Treatment During Convalescence.—As the symptoms begin to disappear and convalescence is established, the necessity for the same rigorous treatment



FIG. 281.—Whitman's Short Stiltting Brace and Plaster Spica Used in the Ambulatory Treatment of Tuberculous Hip-joint Disease. This may be applied with or without traction, as may be desired. (Original.)

lessens. In the Hospital for Sick Children, Toronto, the first change is to give freedom to the spine and to permit some motion at the hip. If the long splint has been employed, the upper part of it is removed and it is converted into a Taylor hip brace. If the short spica and crutch brace have been used, the

spica is dispensed with and the effect of the change carefully watched. If after several months or a year the improvement continues, the complete stilt is replaced by what is known as the caliper brace (Fig. 282). This is simply the Taylor brace from which the foot-piece has been removed and which has been attached to the shoe by a free joint through the heel. By keeping the perineal straps tight, part of the body weight will come on the straps and the rest on the leg. In this way too much work is not thrown on the diseased hip at once.

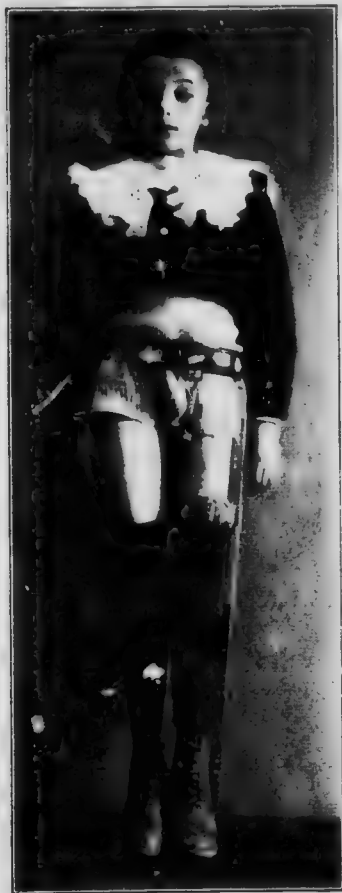


FIG. 282. The Caliper Brace Used in the Ambulatory Treatment of Hip-joint Disease.

Another plan which has proved very satisfactory is to dispense first of all with the stilt. Thus, where the Whitman crutch brace and short spica are used, the crutch brace is first changed to a caliper brace and finally removed, the spica being retained for many months longer. In the case also where the long brace has been employed, it is removed and a spica applied. The spica is first extended down to the ankle, but is later cut off to allow free motion at the knee. An advantage in this form of treatment is that the flexion and adduction that so often occur during the later stages of the disease are entirely prevented by the plaster of Paris.

Finally, if it is found that no exacerbation has resulted from the change in treatment after several months' trial, all apparatus is removed. The patient must be kept at this time under closest observation in order that early information of the fact may be gained in the event of a recurrence. If acute symptoms develop, the patient must be immediately brought back to the original form of treatment and the same process gone through as before.

Correction of Persistent Deformity.—We have yet to consider the treatment of those cases which have been cured with deformity and also those cases which are seen first when the disease is not yet cured and in which there is resistant

deformity. In the latter class of cases, where the disease is still active and where there is ankylosis in flexion and adduction, the wisest plan is to devote the entire attention to completing the eradication of disease before interfering with the deformity. No operative procedure should be attempted until all sinuses are firmly healed and the process of repair is well established. When a cure has been obtained, attention may be turned to the deformity, which is usually flexion, adduction, and external or internal rotation (Fig. 283). In those cases in which there is slight motion, and the head of the bone, or part of it, is still in the acetabulum, an attempt should be made to reduce the deformity by forcible manipulation. The patient is anesthetized and the thigh levered down as described above, the attitude being changed to full extension, slight abduction, and the proper amount of external rotation. A plaster spica is then applied. This should be worn a long time to allow the adhesions, etc., to form in the new attitude and thus prevent recurrence. The patient, of course, is allowed to walk with the use of crutches.

Instead of the forcible manipulation and the application of a spica, a scheme sometimes used is the employment of an abduction brace (Figs. 284 and 285). This consists of an inside bar ending below in the ordinary foot-piece and straps described in the other ambulatory braces, and above in a perineal crutch which fits into the junction of the thigh and perineum on the side opposite to the diseased hip. This crutch is padded carefully to prevent soreness. The upright bar is made in the form of a tube and is extensible by means of a ratchet and key. When the brace is applied and the traction straps have been tightened by extending the inside bar with the key, the leg is forcibly abducted owing to the slight angle between the leg and the bar of the brace. A high shoe is put on the other foot, and the patient is allowed



FIG. 283. Fixed Deformity in Tuberculous Hip-joint Disease. Ankylosis has occurred and the thigh is flexed and adducted, with outward rotation. (Original.)

to walk. By tightening up the traction each day, very resistant adduction deformity can be sometimes overcome, and, if the brace is worn sufficiently long, it will not recur.

In cases where there is upward displacement of the femur, the head having been absorbed or dislocated, or where there is an ankylosis too strong to be

broken down by manipulation, the only treatment of value is subtrochanteric osteotomy. If the deformity is reduced by forcible manipulation it invariably recurs on account of the absence of the outward leverage of the neck of the femur and on account of the contraction of the powerful adductors which are left unbalanced owing to the mechanical obstruction offered to abduction by the proximity of the trochanters and the side of the pelvis.

In performing subtrochanteric osteotomy an osteotome of the variety known as Vance's may be used. It is about one-half inch wide at the edge and the shaft is very small, so that the opening made by it is of minimum size. The osteotome is passed through an incision in the skin at a point just below the trochanter minor on the outer side of the thigh, with the blade in the long axis of the limb. After it has passed through the periosteum it is turned at a right angle to the bone and the outer table of the shaft cut through by a series of little nicks in a line exactly across the femur. When this is completed the



FIG. 284.—Abduction Brace for the Correction of Deformity in Hip-joint Disease. (Front view.)

thigh is levered away from the cut in the bone and broken across. The limb is then abducted and extended and rotated inward to any attitude that may be desired. Before deciding the attitude one must refer to the measurements of the legs and ascertain the exact real and the apparent shortening. If there is no real shortening the limb should be put up in very slight abduction. If there is considerable shortening this may be partially overcome by putting the limb up in more marked abduction, thus producing an apparent length-

ening on the crippled side by tilting the pelvis. The flexion should not be completely reduced, as it is very convenient for the patient to have a little flexion when sitting down. Care must be taken to have the foot and knee rotated slightly outward. When the deformity is corrected, a spica is applied from the mammary line to the toes, and the patient is left in this for about six weeks. In the case of adults it is a good scheme after the plaster is firmly set to cut out the front of the spica from the top down to the umbilicus, leaving the posterior portion to extend up to the mammary line. In this way the obstruction to free breathing and the discomfort after eating are removed without interfering with the efficiency of the apparatus. At the end of six weeks the spica is cut off at the knee to allow movement at that joint, and at the end of eight or nine weeks the plaster is removed and a short spica applied, after which the patient is allowed to walk. This is used for a month or so to make sure that union is firm.

Treatment of Abscess in Hip Disease.—During the progress of hip disease, abscess formation is a frequent complication. So long as it remains quiescent as a closed sac it in no way adds to the seriousness of the condition. If, however, it becomes infected by pyogenic organisms the resulting disturbance proves the most troublesome and most fatal complication of the disease. Infection may take place by communication with the skin surface following incision and drainage, or through the open wound which is left by the bursting of the abscess. Infection frequently takes place also without any break in the skin, owing to the abscess cavity approaching too closely to the surface and communicating with the cutaneous glands and follicles.

When the course of a tuberculous abscess is watched it is frequently seen to grow to a certain point and then to cease growing. Gradually the fluid part of the contents is absorbed, the solid part becomes organized, and finally noth-



FIG. 285. Abduction Brace Used for the Correction of Deformity in Hip-joint Disease (Back view)

ing is left but a slight thickening of the tissues. In other instances the abscess continues to grow rapidly and soon comes close to the skin, burrowing along the paths of least resistance. During all this time there has been no disturbance of the patient from the presence of the abscess, there being no rise of temperature and no local signs of acute inflammation. If, however, infection with other organisms occurs, the clinical picture changes and we have high fever, malaise, loss of weight, and the other links of the hectic chain. Copious discharge often takes place from the sinuses communicating with the abscess cavity, and, if the patient lives, this will probably continue for years. As a result of the long-continued suppuration amyloid degeneration of the viscera is frequently added, and, where this advances very far, death invariably results.

The indications for the treatment of an abscess are based upon these considerations of its clinical course and upon what we know of its essential structure, as already described in our consideration of its pathology (page 580). These indications may be summarized as follows:

First. To keep the cavity sterile.

Second. To prevent its enlargement to such a size as to be injurious.

Third. Where it is large, to remove it and prevent its recurrence.

The plan of treatment adopted aims at following these indications. It is divided into expectant and active phases. When it is discovered that an abscess is developing, the patient is immediately returned to recumbency in order that the possibility that the abscess is developing by reason of insufficient rest at the articulation, may be eliminated. The size of the collection of fluid is carefully noted, and from time to time it is examined to detect any variation in size. If it is found that the abscess does not enlarge much and finally ceases to grow, it is left severely alone in the hope that nature will effect its own cure. If, however, it continues to enlarge, steps are taken at once to head it off in order that, in the first place, there may be a minimum involvement of the soft structures, and, secondly, in order that infection from near approach to the skin may be prevented.

Never allow a tuberculous abscess to get near the skin, is a rule to be remembered, for not only is there danger of mixed infection, but the fact that the tissue between the skin and the abscess is thin makes firm union impossible after incision, and as a result breaking down frequently takes place even after primary union.

A common practice is to aspirate the cavity through a large needle, but this method has nothing in it to commend it, as more certain results are obtained by incision without drainage, carried out in a special manner to be immediately described.

Moreover, the contents of these cold abscesses are often too thick to be withdrawn by means of a needle. In many cases, too, the emptying of the cavity seems to have no effect on the course of the abscess; consequently some-

thing more radical has to be done with a view of removing the disease in the abscess wall.

The usual procedure in such cases is freely to incise the abscess through the thickest part of the tissue intervening between the sac and the skin and opposite the least dependent point in the abscess, and thoroughly to evacuate its contents. If the abscess has approached so near the surface that the tissues immediately over it are very thin, then it is wise to make one's incision sufficiently far from the abscess to cut through a good thickness of healthy tissue before the cavity is reached. This will more efficiently insure primary union after suture than would be the case if the thinner layer of tissue were incised and sutured. The walls of the sac are then dissected out or curetted with a flushing curette. The cavity is finally thoroughly wiped out with iodoform gauze on a clamp, for the purpose of removing as much debris as possible. The wound is then sewn up tight, a deep layer of absorbable sutures being put in to make a thick wall, and a sterile dry dressing is applied.

The results of this plan have been very satisfactory. My colleague, Dr. C. L. Starr, of Toronto, has reported 55 cases treated in this way at the hospital. In seven the wound broke down after being sewn up, and in 48 cases, as far as could be traced, it remained perfectly closed for periods varying from four months to six years. Only 5 of the series required a second evacuation of contents, and 1 a third. In one case the wound healed by primary union, and at the end of two weeks broke down and discharged a quantity of tuberculous material. The cavity of the abscess was then again thoroughly curetted, and the edges of the wound were excised and sewn up tightly. This time firm healing took place, and there has been so far no recurrence.

The greatest care must be taken in the aseptic technique of this operation, as the unhealthy tissues are more liable to infection than normal structures.

The writer has employed this method of treating tuberculous abscesses for the past ten years, and from his experience he would urge that it is absolutely unjustifiable to drain a tuberculous abscess unless mixed infection has occurred. One patient who developed a very large abscess in hip disease was treated in this way six years ago. The incision healed by first intention and there has been no recurrence. Another patient, two years after the onset of hip disease, developed an abscess which approached the surface on the outer aspect of the thigh. It was opened and treated and it healed by first intention. Ten months afterward another abscess developed, on the inner aspect of the thigh; this was treated in a similar fashion and it also healed by first intention. It is now three years since the last operation, and there has been no recurrence, and the child is now going about without a splint.

Various modifications of this treatment have been employed. It was suggested by Mikuliez that abscesses be treated by aspiration and the injection of a ten-per-cent emulsion of iodoform in glycerin; or, if incision and evacua-

tion are employed, to leave an ounce or so of this emulsion in the abscess cavity. This plan was given a thorough trial in various hospitals on this continent, and the consensus of opinion is that it is not of any particular value in the treatment of cold abscess and that sometimes it seems to prevent the collapse of the cavity, after evacuation, by the dehydrating action of the glycerin on the tissue.

It was formerly the custom to mop the cavity thoroughly with pure carbolic acid or some other caustic before closing the skin. This has now been abandoned, as it has no particular advantage.

The pernicious custom of incising tuberculous abscesses and employing iodoform gauze or tubes for drainage purposes cannot be too strongly condemned, as it always ends in infection of the cavity, and long-continued suppuration is the invariable result.

Treatment of Suppurative Hip Disease.—In those cases which have been infected with pus organisms as a result of the communication of the abscess cavity with the skin, the whole secret of successful treatment lies in the provision of perfect drainage. If the pus is unable to find its way to the surface easily it will rapidly strip up the tissues and soon create a honeycomb of sinuses about the joint. If, on the other hand, efficient drainage is provided, there is every probability that the infection will be limited to the area already involved, and in consequence a minimum amount of damage will occur.

When the disease is acute these sinuses should be left alone, the surgeon only interfering to keep the passage to the bottom of the cavity free. The dressing should be done once or twice daily, as the amount of the discharge demands. Drainage may be provided for by gauze or by tubes, the latter being usually the more efficient. When the sinus is long and tortuous a good plan is to use a soft-rubber catheter. On account of its rounded nose this can be slipped in and out without injury to the tissue or discomfort to the patient. When the discharge is profuse it is customary to irrigate the sinus daily. A good method of doing this is to attach the irrigator to the catheter mentioned, and, when the eye of the catheter is at the bottom of the cavity, to turn on the fluid. Normal saline solution is practically always used by the author in the irrigation of sinuses, the theory being that it has all the advantages of the other fluids without their injurious effect on the tissues. It is simply used to wash out the pus.

The treatment as already described for the acute non-suppurative cases must be carefully carried out also in those cases where suppuration is present. In order that the hip may be disturbed as little as possible during the dressings these children may with advantage be provided with the adjustable bed splint described above (Fig. 273). At the region of the hip the outside bar is bent into a loop so that the dressings can be applied and the bandage adjusted without interfering with the fixation of the joint or the traction on the limb.

The plaster spica cannot be used in the majority of cases on account of the discharge of pus.

After the acute stage has passed off, unless it seems likely that extensive necrosis of bone has taken place, it is better to leave the sinuses alone. If there is much dead bone in the cavity this should be removed by curettage or excision of the joint. Frequently the discharge from the sinuses gradually diminishes until nothing is left but a tuberculous fistula. This will remain open for an indefinite time, and the best method of dealing with it is thoroughly to remove the diseased granulations.

Excision of the Hip.—The indications for excision of the hip in tuberculous disease are limited. It should be done where it is otherwise impossible properly to drain the joint, and is specially indicated when amyloid disease becomes evident, and, lastly, when there is reason to believe that there is extensive necrosis of the head or the acetabulum, or both.

A suitable operation for these cases, where perfect drainage is required afterward, is that in which a posterior incision is employed. The patient is rolled over on the sound side, the thigh is semi-flexed and rotated a little inward, and a four-and-one-half inch incision made extending from about two and one-half inches above the tip of the trochanter to a point two inches below. The incision is deepened to the capsule, and the surface of the trochanter is laid bare by separating the glutei muscles. The capsule is now opened and all the muscles on the front of the trochanter and on the back are removed, the leg being rotated to assist this operation. The saw is now applied and the head, neck, and trochanter may thus be removed, if necessary. By this procedure an excellent view of the joint can be obtained and all diseased capsule and bone may readily be excised. The wound is then packed with iodoform gauze to control hemorrhage.

The secret of the success of this operation in saving life is that it provides excellent drainage. In order that this may not be lessened, sufficient traction must be applied to the limb to prevent the extremity of the femur from being displaced upward and thus closing the wound. During the period following the operation, adequate fixation must be provided, with the limb in a correct attitude. This is best gained by the use of the bed splint described above, or by the use of a Thomas splint with traction.

The results following excision are not very satisfactory. At the Hospital for Ruptured and Crippled in New York, Townsend reports 90 cases, with 51.5 per cent of deaths, and Bradford and Lovett report 44 per cent of deaths in 50 cases at the Boston Children's Hospital. These statistics also include cases that were not septic previous to the operation, so that the percentage in this class of cases for which the operation is advocated would be considerably higher. On the other hand, if excision is not performed in these cases, practically all die, so that the operation is frequently valuable as a life-saving measure.

It was formerly a common practice to do an excision earlier in the course of the disease for the purpose of extirpating all tuberculous tissue, and thus it was hoped to cut off several years of treatment. The objections to this plan are so strong that it has been largely given up. In the first place, the mortality is extremely high, ten per cent, according to Wartmann, dying, very soon after the operation, of acute miliary tuberculosis, and many others dying of shock or sepsis. In the second place, one is not always successful in eradicating all the disease, and consequently, after the operation, the conditions are not materially bettered. And, finally, the result, at best, is not a good one, as the joint has been destroyed and its function as a stable support of the body is abolished. Ankylosis in correct attitude is a far better result to aim at than the unstable joint that is left by an excision.

Local Operative Measures.—We have already stated that the removal of limited foci of disease cannot be carried out in the hip as is occasionally possible in connection with tuberculous arthritis in other parts of the body. The exception here is perhaps in certain cases of tuberculous deposit in the outer part of the femoral neck. Symptoms of localized pain in the region of the trochanter major or the evidence of focal disease as demonstrated by an x-ray photograph may lead to the diagnosis of such a lesion, and its eradication may be possible by operative means. We cannot advise this as routine treatment, but in individual cases where the progress, the extent, and the duration of the disease are taken into consideration along with the constitutional condition of the patient, it may be thought wise to cut down upon the trochanter major, and by tunnelling through this into the femoral neck the lesion may be reached. The writer has succeeded thus in reaching a lesion in the outer part of the femoral neck without opening the hip joint, and by this means getting rid of the disease by operation, thus preventing the possibility of invasion of the joint structures. Such an operation, if successfully carried out, will of course secure a perfect functional result so far as the hip joint is concerned.

Amputation.—Amputation may be considered as a last resort after excision has failed to relieve the conditions in suppurative cases. It may be impossible to remove the disease completely because of advanced acetabular involvement, but in extensive disease of the pelvis amputation may be useful in providing conditions under which more efficient drainage is possible. Howse has suggested the removal of the limb in instalments: amputation being first performed at the knee, and subsequently—after the patient has recovered from the operation—at the hip. It is claimed that the removal of the weight of the leg, when the patient is suffering greatly from pain and distress, has a markedly favorable effect upon the progress of the case, so that subsequent amputation at the hip is attended with less shock and is more likely to be successful. It happens very rarely that amputation is necessary in hip

disease, and, when it is so, the conditions must necessarily be very unfavorable for the attainment of a successful issue after such a formidable procedure; hence it is that the mortality after amputation at the hip for tuberculous disease is very high, and it is rare that ultimate and complete recovery takes place after operation. It has been noted that tuberculous meningitis has supervened in certain cases after amputation for hip disease. If all these facts be taken into consideration it must appear evident that amputation can be considered only as a forlorn hope.

The Bier treatment, which consists in producing stasis hyperemia in the diseased joint by bandaging the limb above the articulation, is of course inapplicable in the case of the hip joint because of its anatomical situation. The principles involved in the Bier treatment are discussed at length at page 590, and it is quite possible, if hyperemia thus artificially induced is proved to be of specific value in the treatment of tuberculous disease of the joints, that some means will be found to apply the treatment to the hip. Thus it would appear possible to induce active hyperemia by means of the hot-air apparatus, as this has been shown to have much the same effect as passive hyperemia produced by bandaging.

Lastly, we may note the value of the treatment of hip-joint disease by means of Wright's tuberculin opsonic method. A full description of the method of using this therapeutic agent is described at page 592, and its value in the treatment of tuberculous arthritis is there fully discussed. It has been employed with apparent benefit in these cases, and it is being employed in the Hospital for Sick Children at present, but it is too early to state what the final results attained may be. Sufficient work has been done in connection with this form of treatment to convince one that it is an important and useful adjunct to the local treatment which we have already described.

Double Hip-joint Disease.—Occasionally there exist bilateral manifestations of tuberculous disease in the hip joints. When this unfortunate complication occurs the difficulties of treatment are increased, because obviously many of the methods of dealing with the disease which we have described are inapplicable here. This is chiefly the case as regards the ambulatory treatment, and, as a fact, when double hip-joint disease exists we are forced to treat the patient in the recumbent position throughout the greater part of the course of the disease.

The same principles must guide us in our methods of treatment. Traction and splinting must be employed in the acute stages of the disease. If plaster of Paris is used it must be a double spica, or a double Thomas splint may with advantage be employed. When convalescence sets in and all acute symptoms of disease have disappeared, a double long hip brace may be procured and the patient permitted to go about on crutches, but locomotion in this way is exceedingly difficult as compared with the conditions which exist in disease re-

stricted to one side, as the patient cannot well move about without the use of one sound free limb.

If the final result should unfortunately be that of ankylosis of both hips the patient will walk with difficulty and with a very awkward gait. In such cases it has been suggested that an excision of one hip should be performed with the hope of securing a certain amount of movement.

Involvement of Other Joints in Hip Disease.—Difficulties may arise by reason of such complications. Thus, Fig. 286 is a photograph of a patient with

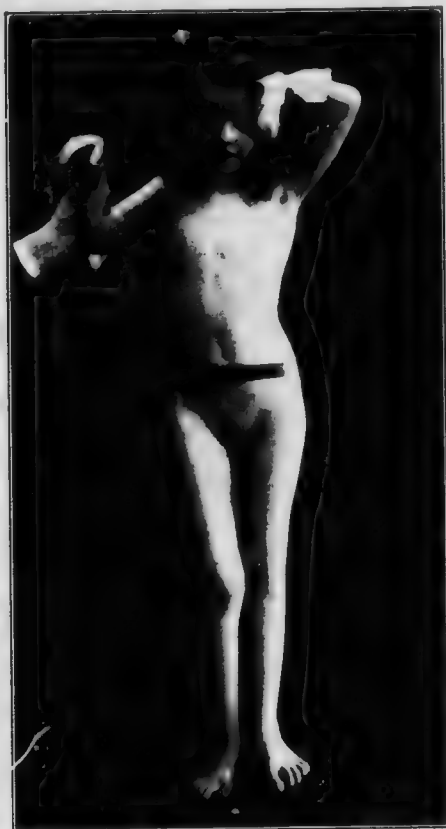


FIG. 286. —Tuberculosis of the Left Hip and Right Knee in the Same Patient. The child was eight years of age. The hip disease developed three years previously and became quiescent, with one inch shortening of the limb, when the knee disease manifested itself. (Original.)

markedly the case in childhood, as is evidenced by the following statistics from the Hospital for Sick Children, Toronto. Of 115 cases of disease of this articulation admitted into that institution the following indicates the conditions found:

knee-joint affection on one side and hip disease on the other. Here, again, the principles of treatment already laid down are to be observed. As in double hip trouble, so here the treatment must be carried out for a much longer period in the recumbent attitude, but in convalescence progression is possible with a combination of a Thomas knee splint on one side and a traction long splint for the diseased hip.

More commonly, Pott's disease of the spine is combined with hip disease. It has been suggested that infection spreads from the spine to the hip by means of a psoas abscess which has reached the hip joint by way of the ilio-pectineal bursa (see page 627). Here, again, the recumbent attitude is necessary for a longer period than in uncomplicated hip disease. When convalescent, however, the patient may get about on crutches with the necessary splints and braces.

Tuberculous Disease of the Knee Joint.—As in the hip so in the knee, the most common affection of the joint is tuberculous disease. This is

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Acute and chronic synovitis	19
Acute suppurative arthritis	7
Arthritis deformans	1
Syphilitic arthritis	3
Hæmophilia	1
Loose cartilages	1
Ankylosis from conditions not determined	7
Tuberculous arthritis	76
Total	115

In these children fourteen years of age and under, therefore, the tuberculous affections amounted to 66.1 per cent of all cases of affections of the knee joint admitted to hospital. In the same institution it was found that, of 315 cases of tuberculous arthritis admitted to the wards, there were 52 (representing 13.2 per cent) of disease in the knee joint. From these statistics it would appear that tuberculous disease of the knee joint is only about one-fourth as common as similar affections of the hip, which, as has already been stated, amounted to 53.6 per cent.

Tuberculous disease of the knee is much more frequent in the adult than is a similar condition of the hip. The fact that this affection is comparatively common in the adult is shown by the statistics of Koenig of 704 cases, as follows:

1-5 years	113
6-10 "	119
11-15 "	101
16-20 "	89
21-25 "	54
26-30 "	39
31-40 "	53
41-50 "	33
51-60 "	25
61-70 "	18
	704

Here, however, as in the hip, the first decade of life gives us the largest number of cases. Thus, in the above statistics, 41.4 per cent of the cases occurred at that period of life.

Anatomical Considerations.—It is not necessary here to describe in detail the anatomy of the knee joint, but reference may be made to some special features of its structure which have a particular bearing upon the course of tuberculous disease.

The knee joint is the most complicated articulation in the human body. It is also the most extensive joint, and this is the case whether we take into account merely the extent of the articular cartilage or the size of the synovial sac. At the time of birth, the articular extremities of the femur and tibia, which here form the joint, are almost wholly cartilaginous, as is also the patella. The centre of ossification for the lower epiphysis of the femur usually appears shortly before birth, and so too may the centre for the upper epiphysis of the

tibia, but the latter is somewhat later in appearing than the former. Ossification does not appear in the patella until the third year of life. Even up to the end of the third year a considerable thickness of cartilage still surrounds the ossific centres in the femoral and tibial epiphyses. The femoral epiphysis includes the condyles and the articular surface of the bone anteriorly. The tibial epiphysis includes the tubercle of the tibia. The disc of cartilage which separates the femoral shaft from its epiphysis persists until the twenty-first year. The plane of the cartilaginous disc is transverse to that of the axis of the femur, and is situated immediately below the adductor tubercle, which may be taken as a surgical landmark in locating it. (Consult also the article on "The Epiphyses and their Radiographic Interpretation," page 578, Vol. I).

Similarly, the epiphyseal cartilage of the tibia, which persists until the twenty-first year of life, lies in a plane at right angles to the axis of the tibial shaft; it

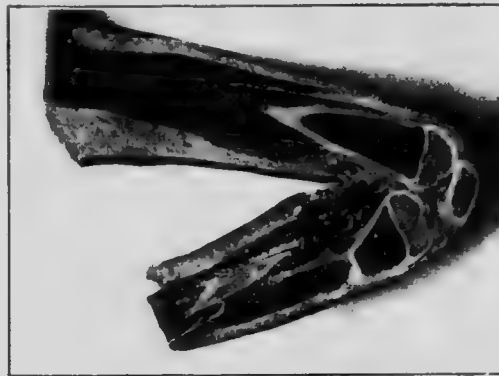


FIG. 287.—Section through the Knee Joint of a Child Nine Years of Age, Showing the Epiphyseal Cartilages. (Original.)

lies for the greater part immediately above the tubercle of the tibia, but dips downward anteriorly to include that tubercle. In Fig. 287 these two epiphyses are seen in a child nine years of age. The growth in length of the limb depends largely upon the persistence of these cartilaginous discs, and if, because of disease or of injury, these cartilages are destroyed, there is great interference with the growth of the bones, and marked disparity will result in the length of the two limbs, the degree of shortening depending, of course, upon the age of the child at the time when the cartilage is destroyed.

The cancellous bone, of which the epiphyses are composed, has a thick covering of articular cartilage both in the child and in the adult. In Fig. 288 the structure of the adult joint is seen in sagittal section. The articulating surfaces are incongruent, since the concavities of the condyles of the tibia are less in depth than would be necessary to receive the convexities of the condyles of the femur. In addition to this the semilunar cartilages (menisci), which are developed on

the articular extremity of the tibia, cover the greater portion of the articular cartilage of the tibia and cut it off largely from direct articulation with the femur. (See Fig. 288.)

Within the articular cavity the two crucial ligaments arise from the intercondyloid fossa of the femur and pass to the non-articular surface on the upper aspect of the head of the tibia. These ligaments are derived from the capsular



FIG. 288. Section through the Knee Joint of an Adult, Showing the Extent and Thickness of the Articular Cartilage and the Synovial Cavity Extending upward under the Quadriceps Extensor Cruris Muscle. (Original.)

ligament of the joint, a portion of the posterior part of that ligament being isolated at an early stage of development by the backward development of the condyles of the femur. The anterior surfaces of these ligaments are covered by synovial membrane. They are strong and well developed and materially strengthen the joint by the firm manner in which they attach the femur to the tibia.

The capsule of the joint is re-enforced by special ligaments. The close relationship of the popliteal artery to the posterior ligament is shown in Fig. 288; this must be borne in mind in operations upon the posterior aspect of the joint. The structures bounding the joint anteriorly consist of the extensor apparatus of the articulation, made up of the quadriceps extensor cruris and its tendon, in the substance of which the patella is developed as a sesamoid bone. The tendon of the muscle passes, as the "patellar ligament," to be attached to the tubercle of the tibia. This patellar ligament is quite shut off from the knee joint by a mass of fatty tissue which develops between it and the capsule; further, a bursa, the "deep infrapatellar bursa," exists immediately beneath the ligament; it does not communicate with the knee joint.

The synovial cavity of the knee joint is very extensive. (See Figs. 287 and 288 on pp. 686 and 687.) It lines the capsule of the joint. The fatty tissue behind the patellar ligament is covered by synovial membrane and projects into the joint on either side of the patella as the alar folds or "alar ligaments." There is also a "patellar synovial fold," which arises from the anterior aspect of the capsule and projects backward to be inserted into the intercondylar fossa; this fold is made up of fat covered by synovial membrane. The largest diverticulum of the synovial membrane is the suprapatellar bursa, which extends upward beneath the quadriceps extensor muscle on the anterior aspect of the femur for about a hand's breadth above the patella. It always communicates with the knee joint. Into this pouch of synovial membrane the suberureus muscle is inserted, and it is separated from the anterior aspect of the femur by a layer of fat (see Fig. 288).

The extent of the synovial cavity in relation to the articular extremities of the bone, and chiefly in relation to the epiphyses, must be mentioned. It will be observed that the synovial membrane does not extend downward below a plane corresponding with the upper surface of the tibial head. Thus it is possible for a tuberculous lesion in the upper epiphysis of the tibia to reach the surface without rupturing into the knee joint, or a tuberculous lesion may be removed by operation in this locality without opening the joint. On the other hand, the synovial cavity extends much farther over the femoral epiphysis. In front, it passes upward as far as the suprapatellar bursa extends, as this bursa is in direct anatomical continuity with the cavity of the joint. Posteriorly, the synovial cavity stops with the articular surface of the condyle. Laterally, however, the synovial cavity is practically confined to a plane corresponding with the upper surface of the head of the tibia, and thus in this region a tuberculous disease of the femoral epiphysis may make its way to the surface without rupturing into the joint cavity, or one may reach a focus in the lower epiphysis of the femur from an incision made on the lateral aspect of the joint without opening the joint cavity.

There are certain bursae about the knee joint, the existence of which must

be borne in mind when examining for disease. Posteriorly, we have one under the popliteus tendon, another under the semimembranosus tendon, and a third under the inner head of the gastrocnemius muscle. The last two may communicate with the joint cavity. Then there are the subcutaneous prepatellar bursa and a bursa which exists between the fascia and the tendon of the quadriceps extensor muscle; also a subcutaneous infrapatellar bursa between the skin and the patellar tendon. None of these last-named bursae communicates with the joint, but the existence of disease in any one of them may sometimes be confused with disease in the knee joint.

Etiology.—We have already discussed the etiology of tuberculous arthritis (page 564), and nothing further need be added regarding the causation of disease in the knee joint.

Pathology.—The morbid anatomy of tuberculous invasion of bone and synovial membrane has already been fully described; there are, however, certain peculiarities in the manifestation of tubercle in the knee in consequence of the extent of the articulation, and particularly of the synovial membrane. The synovial membrane on the anterior aspect of the joint is accessible for palpation, and its condition can be determined by examination in a manner which is impossible in such a joint as the hip, for example, where, because of the depth of the articulation and the thickness of the soft parts covering it, such an examination is impossible. The feature here observable is the great amount of thickening of the synovial membrane which is possible in the diseased joint. The extension of the membrane upward under the quadriceps extensor muscle may, in the diseased joint, be found as a thick pulpy pad of tissue which, when cut into, has a grayish, succulent appearance. The histological changes which are manifest in such a condition of the synovial membrane have been described.

While this condition is so familiar in what is termed "white swelling of the knee," one must remember that at an early stage of the disease this characteristic thickening may not be present; there may be marked congestion of the membrane with effusion, rich in fibrin, into the joint cavity. The fibrin is deposited on the surface of the synovial membrane, and in this tuberculosis develops and subsequently invades the subjacent tissue, and eventually a thickened mass of tuberculous tissues replaces the normal synovial membrane. The synovial villi of the joint also become involved and occasionally form exuberant masses of polypoid or filamentous growths projecting free in the cavity. Pulpy masses of tuberculous granulation tissue also push their way insidiously over the surface of the articular cartilage, which in turn becomes invaded by disease. It is seldom one finds any fluid in the joint once the disease has progressed sufficiently to cause marked thickening of the synovial membrane.

The changes which occur in the bone are those characteristic of the invasion of cancellous osseous tissue by tuberculosis, as already described. Here again the

size of the epiphyses at the knee provides an extensive mass of cancellous bone which may be invaded extensively without a communication being necessarily established with the joint cavity; the disease may in fact reach the surface without opening up the joint. A sequestrum may form in the epiphysis. Such a case is illustrated in Plate XXV, Fig. 1, where a sequestrum is seen in the inner portion of the tibial epiphysis in a child ten years of age. On the other hand, the disease may spread to the cartilage and may eventually cause its destruction



FIG. 289.—Advanced Tuberculous Disease of the Knee, Showing Disintegration of the Joint with some Displacement Backward of the Tibia. The patient was thirty-two years of age. (Original.)

more or less completely; the semilunar fibro-cartilages may similarly become involved or destroyed, while the ligaments about the joint, in extensive disease, may become softened and infiltrated. Thus the disease may go on to complete disintegration of the joint, as shown in Fig. 289, where tuberculous disease in a young adult had produced extensive destruction of the articulation. Invasion and thickening of the articular extremity of the bone are accompanied to a greater or less extent by atrophy of the shaft. Fig. 290 is an x-ray picture

of the conditions which obtained in a lad eight years of age, in which the bones of the thigh and of the leg are markedly atrophied.

The disease may begin primarily in bone or in synovial membrane. It is not always easy or possible to determine the starting-point, but at times one can do this with certainty. Of the 691 cases observed by Koenig there were 632 in which he was able to determine the starting-point of the disease, and of these

281 originated in bone, i.e.,	44.5 per cent
351 in synovial membrane, i.e.,	55.5 " "

The other 59 cases were undetermined.

From these statistics one would conclude that, in the knee, primary tuberculous disease in synovial membrane is more often met with than primary dis-



FIG. 290.—Skiagraph of Tuberculous Disease of the Knee of Long Standing, showing ankylosis in a faulty attitude of extreme flexion, with marked atrophy of the shafts of the bones and enlargement of the articular extremities. The patient was a lad eight years of age. (Original)

ease in the bone, but there is considerable variation in this respect, dependent apparently in some instances on the age of the patient. Thus, pure synovial disease is more common in children and young adults, while in patients over twenty years of age the bone is the more usual seat of disease; and, as age advances, the tendency to the production of sequestra is more pronounced, while in younger subjects caseous deposits are more common.

The position of the osseous deposit in the 281 cases reported by Koenig was as follows:

In the patella, 33 cases, i.e.	11.7 per cent
Femur, 93 cases, i.e.	33.1 " "
Tibia, 107 cases, i.e.	38.1 " "
Several bones, 48 cases, i.e.	17.1 " "

It would thus appear that the tibia is the most frequent site of the primary deposit; next in order comes the femur, while primary disease in the patella is comparatively rare.

Abscess formation is not an infrequent complication. It is not uncommon to find the abscess develop as an extra-articular formation when, as is not infrequently the case, the abscess forms in connection with a primary deposit in the bone which comes to the surface on the lateral aspect of the joint. Fig. 294 illustrates such a case where an abscess had developed from a deposit in the femur without any implication of the joint cavity. Occasionally the abscess may be very extensive, sometimes burrowing beneath the quadriceps extensor anteriorly, or posteriorly among the muscles of the calf. The frequency of suppuration in 689 of Koenig's cases was as follows:

With suppuration.	348 cases
Without suppuration.	341 "

In Gibney's analysis of 300 cases 140 developed abscesses and 160 never had abscesses. It would thus appear that the cases are about equally divided. Here as elsewhere the serious nature of abscess as a complication depends mainly upon whether the abscess remains as a purely tuberculous process, or whether mixed infection supervenes; in the latter case the prognosis is much more grave. The point has already been fully discussed (page 645).

Symptomatology.—The symptoms will necessarily vary according to the stage in the progress of the disease at which an examination is made; or, again, these symptoms may differ in primary synovial disease from those present in primary osseous disease. We find the same group of symptoms in disease of the knee that have been already described in hip-joint disease. In the case of the knee, however, the joint is much more accessible for examination than is the hip, and it is possible here to differentiate between lesions of synovial membrane and those of bone in a manner not possible in the hip. In adults the disease not infrequently begins with symptoms of chronic synovitis with effusion into the joint. This condition may persist for months before definite symptoms suggestive of tuberculous disease manifest themselves.

In a typical case of white swelling of the knee we have a clinical picture presented which is very characteristic. In cases in which the synovial membrane is involved—and in most instances, where at all events the disease has not been checked at an early stage in its development, this structure is affected—

knee will present a fusiform shape which is in marked contrast with the normal contour of the parts above the joint. The bony prominences, which are visible upon the sound side, have been effaced; the depressions on the lateral aspects of the patella are obliterated; and the circumferential measurements are found to be increased. These conditions are seen in Figs. 291 and 292, which represent tuberculous disease in the knee in a child three years of age.

The faulty attitude assumed at the knee in tuberculous disease consists of flexion, as is the case in other joints similarly affected. The amount of flexion may not be great, perhaps ten degrees, but it is found impossible completely to



FIG. 291.—Tuberculous Disease of the Knee Joint in a Child Three Years of Age, Showing the Characteristic Fusiform Enlargement of the Knee and the Attitude of Flexion. (Original)

extend the joint. It is therefore obvious that there is a limitation of movement, and this is not only true of extension, but also of flexion, for we find that complete flexion, which should permit the heel to come back against the buttock, is impossible. Any attempt to bring the joint into a position of complete flexion or complete extension is resisted by muscular contraction. At later stages of the disease, when the ligaments become infiltrated and lax, a varying degree of actual deformity is produced at the knee. The flexion persists while the head of the tibia is drawn backward by the hamstring muscles and rotated outward. This deformity is very characteristic, and is quite constantly present in progressive disease unless measures are taken to prevent its occurrence.

Fig. 203 illustrates the deformity which was present in an adult thirty-two years of age, the disease having existed for six years. In the case figured, the deformity could, of course, not be overlooked, as it is very marked, but one must examine carefully for minor degrees, as the condition when slight is very apt to be overlooked. In the cases of advanced deformity of this nature there may be complete dislocation backward of the head of the tibia, while the flexion may be extreme. Further, the joint may be eventually fixed in the deformed position by fibrous or bony ankylosis. Fig. 200 is a skiagraph from



FIG. 202.—Tuberculous Disease of the Knee Joint in a Child Three Years of Age, Showing the Characteristic Fusiform Enlargement of the Joint. (Original.)

the knee joint of a boy aged eight in whom the joint had become fixed in the attitude described.

Atrophy of the limb is a prominent feature early developed in tuberculous disease of the knee. The skiagraph above referred to (Fig. 200) shows marked atrophy of bone in a long-standing case, but the most notable manifestation of atrophy is in the muscles. Circumferential measurements will show this to be the case when we compare the measurements of the calf and thigh on the diseased side with the corresponding ones on the sound side. The atrophy may be observed by mere inspection, but one is apt to form a wrong estimate of the

degree of atrophy on the one hand and the extent of swelling about the knee on the other, because the wasting of the muscles of the thigh and calf throws the swollen joint out with still greater prominence, leading perhaps to an erroneous estimate of the actual degree of swelling present (for illustration, see Fig. 201), and, again, the degree of atrophy may be erroneously estimated because of the contrast existing between the enlarged joint and the size of the thigh and calf. When one palpates the muscles of the thigh or calf, they feel flabby as compared with the muscles of the sound limb. The nutrition of the skin is also impaired.

The length of the limb in tuberculous disease of the knee may be affected in the production of either shortening or lengthening. It would appear that lengthening is by far the more common condition in the early stages, but, as



FIG. 203. — Advanced Tuberculous Disease of the Knee Joint in a Patient Aged Thirty-two. There is marked subluxation of the head of the tibia, with rotation of the leg outward. (Original.)

time goes on, in consequence of the malnutrition of the limb and retardation of growth as compared with the sound side, shortening results, or it may be produced by actual destruction of the joint structure. Lengthening of the limb is undoubtedly due to increased activity at the epiphyseal cartilage, brought about by the irritation caused by the disease. Increase in length of the diseased limb was first observed many years ago, and Dr. Sydney Jones, in presenting such a case before the Pathological Society of London in 1875, makes the following interesting observation: "In some few excisions of the knee seen some time after operation the author has been struck by the fact that such growth of the limb had occurred as to make the amount of shortening much less than was noted immediately after the operation."

The pain and instability from which the patient suffers vary in different cases. There is usually well-marked though slight increase in heat in the diseased joint. Even where no actual displacement of the bones has occurred, there is still some lameness, the patient moving about with slight flexion of the joint and complaining of feeling tired after slight exertion. There may be little or no pain, but after a time the joint becomes stiff and the limitation of movement becomes more marked.

Where the disease is primarily synovial and is confined to that membrane one is able to define readily the pad of thickened tissue which represents the suprapatellar pouch. The upper limitations of this pouch are readily felt and can be rolled under the examining fingers. The thickened membrane has a soft, elastic feel, but does not fluctuate. There is no enlargement of the bone; there is usually very little pain; but there is necessarily some restriction of movement. One feature of this synovial type of the disease is the early and rapid occurrence of muscle atrophy. The disease in the synovial membrane may be distinctly localized, and occasionally pedunculated masses of tuberculous tissue may project themselves into the suprapatellar pouch from the synovial membrane; they appear to arise most frequently in the region of the semi-lunar cartilages. Such structures have been mistaken for "loose bodies," but they are usually of larger size and are attended by some thickening of the synovial membrane in their immediate neighborhood.

Where the osseous tissue is primarily affected we find a varying degree of thickening of the bones. In the early stages and where the disease is limited to a small focus there may be a localized area of tenderness found on pressure, and such foci should be very carefully sought for in cases in which early disease is suspected. These foci are most commonly found in the femoral condyles, more frequently the internal condyle. Occasionally it is in the head of the tibia, and still less often in the patella. The x-ray will often help to establish a diagnosis otherwise doubtful.

The most acute symptoms of knee-joint disease are found in those cases in which the tuberculous process begins in bone, and, after persisting for some time, suddenly breaks into and invades the joint cavity. Great pain is experienced in such cases, and the joint becomes flexed and is held rigidly by muscular spasm. These cases, as a rule, go on to rapid destruction of the joint structures, with infiltration and thickening of both bone and synovial membrane, while muscle atrophy is pronounced. The characteristic deformity of dislocation backward and rotation outward is brought about as the ligaments become softened and relaxed.

Abscess formation may occur, and this may be either extra-articular or intra-articular. The former most frequently arise from a deposit in the bone which has come to the surface without invading the joint cavity. Such a case is shown in Fig. 294, that of a patient six years of age who had a lesion of the

internal femoral condyle, and in connection therewith an abscess which came toward the surface. The abscess was treated in the usual manner without drainage, and it healed by first intention, the child recovering eventually with perfect functional result so far as the joint was concerned. Fig. 250 represents a microscopic section of a portion of the wall of the abscess in this case. Then, again, an abscess may make its way into the joint cavity, either from synovial membrane or from bone. In such cases the symptoms of acute involvement of the joint come in evidence; there is much pain, and often night cries are



204. Tuberculosis of Left Knee Joint in Child Aged Six Years. The swelling of the inner side of the knee is the abscess which healed by first intention after evacuation in the manner described in the text. (Fig. 250) This section is a section of part of the abscess wall. (Original)

troublesome complications. These cases again usually go on to extensive joint destruction.

Cases may go on to recovery with marked deformity. These are cases which have not been subjected to efficient treatment. It is not uncommon in hospital practice to have patients admitted in whom the disease has become quiescent, but with the joint ankylosed in a position of flexion with dislocation of the tibia backward and rotation outward. In some of these cases the flexion may be so extreme that the limb is useless as a means for progression.

Knock-knee may also occur as a late deformity in patients who have at-

tempted to go about and use the limb when fixed in the deformed attitude of rotation outward and backward dislocation. Then, again, destruction of the internal condyle may in rare instances produce genu varum.

The degree of constitutional disturbance in tuberculous disease of the knee varies greatly. Most frequently the disease is purely local and there are no constitutional effects discernible. In acute manifestations, however, the temperature becomes elevated and the pulse quickened, with general malnutrition. If mixed infection occurs, then symptoms of septic absorption speedily appear, and from long-continued suppuration the usual train of symptoms supervenes; visceral disease, with amyloid changes in the kidneys, liver, etc., may eventually prove fatal.

Diagnosis.—It is not a difficult matter, as a rule, to diagnose a tuberculous knee joint. The symptoms, which have already been detailed, are sufficiently characteristic. Careful inspection and accurate measurements must be made, while by manipulation localized or diffuse swelling may be determined, and the existence, or otherwise, of points tender on pressure may be noted. It is important to observe, not only a faulty attitude, but any limitation of movement which may exist.

The x-ray is a very important aid to diagnosis. This is particularly useful in suspected localized deposits in the bones. It has been already stated that the x-ray picture may show diffuse thickening of bone, atrophy of bone, abscess in bone, or the existence of a sequestrum (*vide* page 648). A sequestrum is shown in Plate XXV, Fig. 1, and at the same time the skiagram (Fig. 2) of the normal knee is shown for purposes of comparison.

Conditions Which May be Confused with Tuberculous Disease of the Knee Joint.

Injuries of the Knee.—Sprain of the joint may cause lameness, with swelling and pain, while the knee is retained in a position of flexion. The symptoms rapidly disappear with appropriate treatment, and thus tuberculosis is excluded; but one must remember that such injuries may predispose to tuberculous disease, especially in sickly children.

Synovitis.—In cases of synovitis of recent traumatic origin there is, of course, no difficulty in determining the diagnosis. In simple synovitis of a non-septic character there is effusion of fluid in the joint cavity, a condition uncommon in tuberculous disease. Here too the amount of thickening of the synovial membrane in proportion to the degree of swelling of the joint is very slight as compared with that in tuberculosis. It must be remembered that chronic synovitis persisting for a lengthy period often becomes the starting-point of tuberculous disease. The acute symptoms which supervene when a focus of disease in the bone suddenly bursts into the joint cavity may simulate acute synovitis, but the previous history of the case will clear up the diagnosis.

Inflammation of Bursa about the Joints.—Careful examination of the joint will show that it is not involved, there is no fluid within the joint, and the synovial membrane is not thickened.

Acute Epiphysitis; Infective Arthritis.—Here we have a history of sudden onset with marked constitutional disturbance and physical signs of local acute destructive inflammation. Confusion, therefore, with tuberculosis should not arise.

Loose Cartilage in the Joint.—The pedunculated masses of tuberculous tissue to which we have referred, and which may be present in the joint, might be mistaken for loose cartilage. The tuberculous masses are larger, as a rule, and there is a history of gradually increasing disability, while in loose cartilage one usually has a history of sudden attacks of pain with locking of the joint and effusion into the joint cavity.

Charcot's Disease.—The disease is associated with *tabes dorsalis*, it is often polyarticular while it is rare to have tuberculous disease in more than one joint. Further, it is more common in adults, and the reverse is true of tuberculosis. Effusion occurs somewhat suddenly into the joint, and destructive processes extend rapidly, producing marked weakness of the joint, with deformity. Pain is usually very slight, and muscular spasm is absent.

Arthritis Deformans. This is more common in adults, especially when it is of the monarticular form. Creaking may be present on moving the joint. The synovial membrane is not markedly thickened; there is early enlargement of the joint and deformity of bone. Goldthwait has shown the great value of the *x-ray* photographs in determining the various manifestations of this form of arthritis in both the hypertrophic and the atrophic forms. In the former the irregular conformation of the articular extremity of the bone is demonstrated, and in the latter there are the atrophic changes.

Hæmophilia.—The hæmophilic joint is produced by hemorrhage into the joint. The history of the patient, showing the fact that he is a "bleeder," in most instances suggests the diagnosis. Fig. 295 is a photograph of such a joint occurring in a boy aged ten years. There may be some inflammatory symptoms accompanying the absorption of the clot.

Rheumatism.—In the child this may be confined to single joints, and then may be mistaken for tuberculous disease. There are, as a rule, marked constitutional disturbances in rheumatism, and the local pain and disability at an early stage are more pronounced. Sooner or later other joints, as a rule, become affected.

Syphilitic Joint.—The form of chronic synovitis which occurs occasionally in syphilis is not likely to be confused with tuberculosis. The history of the case and the progress of the disease enable one to make a diagnosis. Gummata, when they occur about the knee, usually begin in the subcutaneous tissues, and when they appear in the deeper tissue they are found as isolated nodules.

as a rule. The form of syphilitic synovitis to which reference has been made is usually symmetrically developed, so that both knees are involved.

Sarcoma.—A growth of this nature usually begins near one of the epiphyses and may be mistaken for tuberculous disease. If it is periosteal in origin it appears, as a rule, as a more or less localized and irregular bony tumor, but the more centrally the growth is placed the more likely is it to be mis-

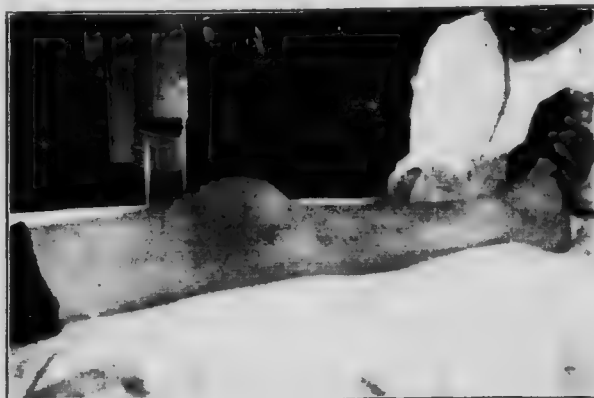


FIG. 295. - Affection of the Knee Joint in Hemophilia, Showing the Enlargement of the Joint which in these Cases may Simulate Tuberculous Disease. The patient was ten years of age. (Original.)

taken for tuberculous disease in the knee. Such growths make rapid progress, however, and their true nature soon becomes evident in that way. In sarcomata certain very characteristic signs may be present, such as eggshell crackling and occasionally pulsation.

Hysterical Joint.—The disability of the joint may simulate tuberculous disease, but the local physical signs of a positive character are absent.

Complications.—The fact that an individual suffering from tuberculosis localized in a joint may become the victim of tuberculous disease elsewhere in the body, has already been discussed in connection with hip disease (page 652). Tuberculous meningitis or disseminated miliary tubercles, pulmonary tuberculosis, etc., may supervene.

Here, too, the importance of recognizing the grave consequences of the occurrence of mixed infection cannot be overestimated. This most frequently results from organisms, other than the bacillus of tubercle, gaining access to a tuberculous abscess. Long-continued suppuration results in destructive septic processes, locally, and general septic infection which frequently has a fatal termination.

Prognosis.—Conservative treatment in average cases affords an excellent prospect of a good functional result. The earlier treatment is instituted and the more efficient it is the better the chances of success. The constitutional

state of the patient necessarily affects the issue. Thus, in weakly children the outlook is not good, and in the face of a strong hereditary history of tuberculous disease one would not give a favorable prognosis. The function of the joint may be preserved in a large proportion of the cases, and this is particularly the case in children, while in the adult the results obtained have not been quite so good. Gibney's statistics, published in 1893, show the results obtained in 300 cases (87 per cent being children). The following results may be tabulated in 242 of the cases treated by conservative methods:

	Cases.	Motion Retained.	Anky-losed
Where no apparatus was used or where such was inefficient	60	44 (73 per cent)	16
Where joint was more or less efficiently splinted, but not prevented from impact with the ground	145	113 (77 per cent)	32
Where joint was both splinted and protected from jars and mechanical treatment was efficient	37	34 (95 per cent)	3
Totals	242	191 (79 per cent)	51

In 191 of the cases that recovered with a movable joint, 74 had had abscess formation. In the 191 cases also it was noted that the limb was practically straight in 125 (65 per cent). In 49 others the flexion was less than 25 degrees, and in but 16 could the deformity be classed as bad (8 per cent).

The tendency to relapse after apparent cure is not great; thus Gibney found relapse in only 10 cases.

Shortening is less likely to occur than is the case at the hip, but, of course, when it does occur, it may be very much greater, as the growth of the limb in length at the lower epiphysis of the femur is much greater than at the upper, and disease at the knee, leading to destruction of that epiphysis in a growing child, produces eventually great disparity in the length of the two limbs. Fortunately, however, the epiphyseal cartilage is not often destroyed.

The length of time necessary to effect a cure cannot be estimated with accuracy, but it may be stated that, as a rule, from one to two years must elapse after the acute symptoms have disappeared before retentive apparatus can be abandoned.

The mortality in knee-joint disease in Gibney's cases was 13.3 per cent. The cause of death was as follows:

Tuberculous meningitis	6
Exhaustion from prolonged suppuration	11
Pulmonary tuberculosis	3
Dysentery	2
Amyloid disease	2
Intercurrent affections not connected with the disease	12
Shock after excision	1
	40

The prognosis here is affected materially when abscess develops, because the danger of mixed infection is greatly increased, and, under such circumstances, the chances of a favorable issue are greatly diminished.

Treatment.—The principles already laid down for the treatment of tuberculosis in the joints (page 586) are applicable to the knee. The method of applying these principles, however, must of necessity vary in the individual joints because of the difference in structure, in position, and in the function performed by each articulation. Thus, in the knee, the question of the advisability of operative interference with a view to eradicate the disease must be considered more favorably than in the hip, because of the greater ease with which a focus can be reached and the possibility of removing it without damaging structures, which, if destroyed, would interfere with the function of the joint. The general rule is to employ the conservative plan of treatment in children and in those who can properly afford to wait the necessary time for this slower method of obtaining a cure, but in the adult who wishes rapid relief it is often justifiable to cut the morbid process short by the extirpation of the nidus, especially when the disease is brought under observation early and is confined to the bone; or this may be accomplished by crasion (arthrectomy), or excision, according to the degree of involvement of the joint structures in more advanced cases. The fact that tuberculosis of a joint is apt to be more destructive in adults than in youth prompts comparatively earlier operative action in the former. In children it is wise to refrain from operation whenever possible because of the shortening which often results from interference with the epiphyseal cartilages, and because of the lessened possibility of retaining good motion after the joint has been opened.

Conservative Treatment.—The conservative treatment must be guided by the same principles as those which have already been stated in the sections relating to tuberculosis of other joints. Rest is provided by splinting, and protection by the use of a stilted brace. Confinement to bed is not usually necessary for more than a few weeks, and, unless the case is very acute, may be dispensed with.

The most efficient knee splint is the light skin-fitting plaster-of-Paris bandage. It should extend from the ankle, or in very acute cases from the toes, to the groin. In the upper part of the thigh it must be applied tightly and as high up as it is possible to apply it comfortably, so that the longest lever possible may be controlled by the splint, and consequently the least amount of motion permitted. Even when this dressing is perfectly applied, a small amount of motion at the knee can still be carried out owing to the softness of the tissues about the femur, which renders absolute fixation impossible.

The method of application is as follows: A long white stocking, or some tight-fitting seamless shirting, is drawn over the leg. If these are not available, a flannelette bandage is snugly applied. Over this two or three plaster bandages are rolled, the greatest care being taken to avoid wrinkles, and the bandage being made as close-fitting as comfort will allow. It is wise to make the bandage especially thick just above and just below the knee, the points of

greatest strain. Enough of the shirting or flannelette may be left at the top and bottom to be folded back over the edge of the plaster and thus act as a protection against excoriation. If necessary, strips of steel or basswood may be incorporated to strengthen the weak points of the splint. It sometimes happens that the leg is of such a shape that, when the patient stands up, the plaster slides down toward the ground. This may be prevented by applying adhesive plaster to the leg and by leaving one end of this free to be incorporated in the plaster as it is applied. Thus the plaster of Paris is fastened to the leg by means of the adhesive plaster. To prevent the plaster from rotating freely about the leg it should be carefully moulded into the depressions about the patella.

Splints of other materials may be used, such as poroplastic, leather, and so on; they accomplish practically the same purpose, namely, the prevention of motion at the joint.

The best mechanical appliance used for lifting the body weight from the diseased knee is the Thomas brace (Fig. 296). It consists of two upright rods of light steel made to conform roughly to the shape of the inside and outside of the leg. They end below the foot in a leather-shod foot-plate, and above they support a padded ring which fits about the junction of the thigh with the trunk. The ring is of an oval shape, flattened in front and expanded behind to take in the lower part of the buttock. It is attached to the uprights at a lateral and an antero-posterior inclination. The lateral inclination makes it lie about parallel to Poupart's ligament, and thus it receives the body weight throughout its whole circumference, while the posterior dip allows of better support to the tuberosity of the ischium. Fastened to the uprights are transverse leather straps which pass in front of and behind the knee and ankle and serve to steady the limb in the brace. Attached to the highest point of the ring is a strap which passes over the opposite shoulder and prevents the brace from sliding down the leg. The foot-plate is provided with a heel strap exactly like that of a hip brace, for the purpose of holding down the heel and preventing the toe from touching the ground, and, in those cases in which a plaster bandage is not used,



FIG. 296. — The Thomas Knee Brace.

traction straps are also attached with the idea of providing more perfect fixation of the knee. When traction straps are used, the adhesive plaster is attached to the leg exactly as in hip disease, except that it does not extend above the

knee. (See photograph of apparatus in hip disease, Fig. 268.) The brace is made so that when it is applied the foot is separated from the ground by two and one-half or three inches. To make the pelvis level again, a corresponding thickness of cork is inserted between the inner and outer soles of the opposite shoe.

As a rule, the aim is to combine the two principles of fixation and tilting. This can very conveniently be done by the plaster-of-Paris bandage worn under a Thomas knee splint. The plaster bandage may be made very thin and light, since practically no strain will fall upon it.

Reduction of Deformity in Early Knee-Joint Disease.—As in hip disease so in knee-joint disease, the deformity is of several varieties. In the early stages, as already pointed out, simple flexion exists, correction of which is resisted by muscular spasm. Later, this flexion becomes a more fixed deformity dependent upon muscular contraction and adhesions. Finally, in neglected cases, where the disease is far advanced, the fixed deformities of flexion, external rotation and posterior subluxation, appear, and an ankylosis of a fibrous or bony character usually adds to the difficulties of correction.

In dealing with deformity maintained by muscular spasm, we have at our command two useful agents in traction and fixation. Traction is employed with a view of reducing the spasm by tiring out the muscles. To accomplish this, the line of pull must be directly in the line of deformity, otherwise the purpose of the surgeon will be defeated. If the pull, for example, be made in the direction of a line joining the heel and ischium, as one might be tempted to do, a lever is produced with the fulcrum at the point of insertion of the hamstring muscles, and the arms of the lever between this point and the knee and foot respectively. As a result of the action of this lever, the intra-articular pressure would be increased and the muscular spasm correspondingly aggravated. We must, therefore, provide for traction in the line of deformity, and for this purpose many schemes have been devised. A convenient one is the traction frame described on page 664 (Fig. 276) for the reduction of deformity in hip disease. To make this suitable for knee-joint cases, the straight frame in which the leg lies is replaced by one which is jointed at the knee. By means of this joint the frame is made to conform to the flexion of the knee. Traction is then applied by the weight-and-pulley apparatus in a line exactly parallel to the lower arm of the jointed frame. When several days have passed, the frame is lowered slightly and the angle at the joint increased until the muscular spasm again is evident. Day by day this manoeuvre is repeated, and at the end of a couple of weeks the deformity should have entirely disappeared.

Fixation is also useful in overcoming the flexion. When the case is first seen, a plaster-of-Paris bandage is applied from the toes to high up on the thigh, or even up over the pelvis, in the form of a spica with the knee in the attitude of deformity. The patient is allowed to lie in a recumbent posture for two or three weeks and then the splint is removed. As a rule, when the plaster is

removed one finds that the deformity can now be corrected very materially; usually it rapidly disappears under this form of treatment.

As in hip disease, the traction method may be used when the disease is not very active, but in the more acute cases the fixation method is the better.

When deformity will not yield to such treatment, more forcible measures must be employed. The point to be remembered in applying force to a stiff knee is that it is often easy to produce a posterior dislocation of the joint while endeavoring to stretch the shortened hamstrings. Any forcible means of straightening a knee must therefore provide against posterior dislocation.

The plan suggested by Whitman is an excellent one. The patient is anesthetized upon an ordinary operating table and rolled over on his face. The

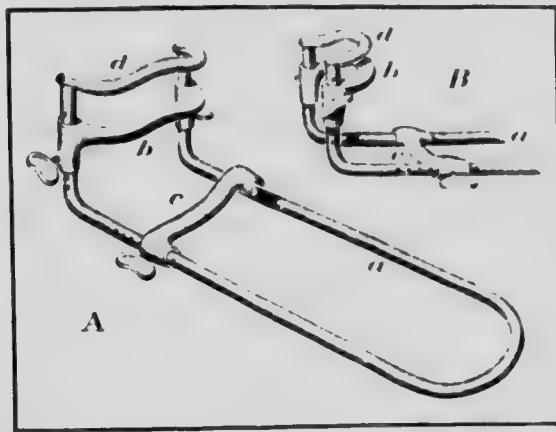


FIG. 297. —The Peters Wrench for the Forecible Correction of Deformity. It is fully described in the text.

patient is raised into the knee-chest position and the operator grasps the leg with one hand just behind the head of the tibia and the other on the ankle. A thick pad or a rolled-up blanket is placed under the leg from the knee to the ankle for the purpose of protecting the knee and shin, and the foot is allowed to hang over the end of the table. An assistant then gently, but forcibly, pushes the thigh with a pump-handle action downward upon the table, bringing it into line with the tibia and correcting all flexion at the knee, the operator in the mean time holding the leg tight against the table. Thus the hand which forces the head of the tibia down on the table prevents all posterior dislocation. This method is better in most instances than that in which the various wrenches are used, as one is able to gauge more accurately the amount and direction of the force employed.

Several excellent mechanical devices have been invented for the forcible reduction of these resistant deformities. The best of these are the wrench devised by Dr. Peters, of Toronto (Fig. 297), and the genuclast of Dr. Goldthwait.

of Boston. Both of these contrivances are levers extending from above the knee to below the foot. The fulcrum is the anterior surface of the lower end of the femur, while the point of pressure is behind the upper end of the tibia. By fastening the ankle in the wrench, the whole leg may be used as a lever and enormous force exerted in breaking down a partially ankylosed joint. The fact that the point of pressure is behind the head of the tibia, close up to the joint, prevents the occurrence of posterior dislocation.

The wrench devised by my colleague, Dr. G. A. Peters, and to which reference is made above, is represented in Fig. 297. It is made of round bar steel five-eighths of an inch in diameter. The apparatus is equipped with two movable bars, one (*b*) upon the upright limbs of the wrench, the other (*c*) upon the horizontal limbs. The bar (*b*), as shown in the figure, is bent toward the body of the wrench and away from the vertical bars to the extent of about an inch and a half, and is provided with two thumb-screws which fit into small depressions on the upright limbs so that it can be set accurately in any desired position. The bar (*c*) is attached by a close-fitting collar to one limb only of the horizontal portion of the wrench, the other end of the bar having merely a concave groove which fits upon the opposite limb. This bar is, of course, also provided with a thumb-screw. By this means the bar can be opened out completely, so as to allow the wrench to be slid over the foot and up the limb to any desired position between *b* and *c*. The bar (*c*) is made slightly concavo-convex on its upper surface, so as to fit the limb, while bar (*b*) is also concavo-convex on its upper surface for the same purpose. It will be observed that the bowing of the bar (*b*) toward the body of the wrench allows the two bars (*b* and *c*) to be practically placed one under the other when in position on the limb, and thus the fullest possible extent of short leverage is permitted. When the wrench is in actual use, further protection may be afforded the parts by placing blocks of "rubber sponge" between the bars (*b* and *c*) and the limb. The length of the wrench is about two feet, and the width between its limbs, from centre to centre, five inches.

Either of the above methods of reduction by force may be used where subluxation has already occurred and where the ankylosis does not seem to be too strong to be broken down. In cases where the ankylosis is too firm, the amount of dislocation will not increase, but it is practically impossible to reduce what has already occurred.

Treatment in the Convalescent Stage.—When the acute symptoms have subsided, the treatment becomes less rigorous. It is the custom with the author to dispense first with the plaster bandage and allow the patient to go about in the Thomas knee brace for a time. After several months have elapsed, if no setback has occurred, the brace is changed to a caliper brace. This is simply a Thomas knee brace, which, instead of extending below the foot, is fastened to the shoe; the upright bars are turned in and fastened to the heel

of the boot. The brace is made about one-half to three-fourths inch too long for the patient, so that at each step part of the body weight is still sustained by the ring at the groin, and the patient's heel does not quite reach the bottom of the boot. When this has been worn for several months longer, and all muscular spasm, heat, and tenderness have disappeared, the brace may be removed. The case must be watched very closely for any return of the symptoms, and if these should occur the first treatment described must be resumed.

Another plan which may be adopted in the convalescent stage is first to remove the Thomas knee brace and allow the patient to walk about with the plaster bandage still in place. Later on, if no acute symptoms appear, this too may be removed. This method answers well in certain cases, but, as a rule, the former of the methods here described is the safer.

Treatment of Abscesses in Knee-Joint Disease.—At any time in the progress of the disease, abscess may develop, and treatment as described on page 677 must be carried out. The development of an abscess must be watched with the greatest care, and if it is extending it must be opened and evacuated; then as much of the tuberculous tissue as possible should be removed by scissors or curette, and the cavity thoroughly wiped out with iodoform gauze, the incision may then be closed with deep and superficial sutures without drainage.

If mixed infection of the abscess cavity takes place from any cause, the aspect of the case immediately changes, and the attention of the surgeon must be directed toward securing efficient drainage. Further operative interference than this is unwise while an abscess exists.

The Reduction of Deformity in Neglected Cases.—When the disease has gone on untreated until the typical deformity has developed, and the limb is fixed in faulty position, operation is required to make the leg straight. The deformity is practically always marked flexion and external rotation, combined with more or less posterior dislocation of the tibia. It is not wise to attempt the treatment of this condition while active disease is still present; and one should wait until all sinuses are closed, before any attempt is made to straighten the limb.

In certain cases where the ankylosis is not very strong and the deformity not too great, the methods described above, for the forcible reduction of the earlier deformities, may be employed. It is, however, often necessary to divide the hamstring tendons in order that reduction may be made possible. This should always be done by way of an open incision, as the danger of dividing the external popliteal nerve is too great to allow of subcutaneous tenotomy. It is a good plan to make it a rule to expose this nerve to view before dividing the tendon. If the operator does this he will have no anxiety about the transient paralysis that sometimes follow the reduction of the deformity.

In those cases in which the deformity is of a firm, fibrous, or bony character, osteotomy will be required to accomplish its correction. The osteotome is

introduced on the outer side of the lower end of the femur about one-half inch above the epiphysis. The instrument is introduced with the edge in the long axis of the limb, and, when pushed through the periosteum, is turned transversely to the line of the femur. The cortex of the bone is then cut through on the outer side and as far across the front of the bone as possible. The femur is here broken through by flexing the leg, and the deformity reduced by traction, while force is applied over the knee. If the deformity is great, supplementary tenotomy of the hamstrings may be required. In extreme cases it is customary to accomplish the reduction of the deformity at two or three sittings, a little being accomplished each time, as the danger of rupturing large vessels is too great to allow of the whole deformity being reduced at once. The method employed is to go about half way the first time, and to do the rest in a week or two, when the tissues have become accustomed to their new attitude. At the same time the external rotation may be partially overcome by rotating the limb inward at the line of osteotomy.

After the correction of the deformity, the limb is put up in a plaster-of-Paris bandage which is retained for about two months. It is prudent, indeed, to keep it on for a much longer time, the patient being allowed to walk about after the first two months. In this way any tendency to recurrence is prevented.

The Bier Treatment.—The method of treating tuberculous arthritis by passive hyperemia has already been fully described (page 590). This means of dealing with a tuberculous knee may be used with advantage. It may be combined with the various methods recommended for the conservative treatment of the condition.

Wright's Tuberculin.—The value of this method of treatment has been discussed (page 592), as has also the technique of its employment. At present it is being used in the Hospital for Sick Children, Toronto, but it is too early to speak authoritatively as to results.

Constitutional Treatment.—Whatever local treatment is employed and whatever stage of the disease is under observation, one must here, as in all cases of tuberculous arthritis, see to it that the patient is placed in the best hygienic surroundings, and that he has appropriate constitutional treatment.

OPERATIVE TREATMENT.

The operative treatment of knee-joint disease requires careful consideration. A few cases occur in which the presence of localized swelling and tenderness in a condyle or over the head of the tibia, and the absence of synovial thickening, indicate the confinement of the process to the bone; and the diagnosis of localized disease may be further confirmed by the x-ray. When this occurs in the inner condyle of the femur it is wise to attempt the total extirpa-

tion of the focus of disease. Should the diagnosis be wrong and the condition eventually prove to be the result of a chronic osteomyelitis or of a tumor, the operation will still prove to have been justifiable, as it constitutes the best treatment of the former and allows an early accurate diagnosis of the latter. If the diagnosis of localized tuberculosis prove correct, the result of operation may be brilliant. The disease may thus be eradicated and a perfect functional result obtained.

Removal of a Tuberculous Focus from the Epiphysis.—In removing a tuberculous focus from the epiphysis of the femur or tibia, care should be taken to avoid opening the knee joint. The incision should be vertical and made laterally where the synovial cavity does not extend up and down, as it does on the front and back of the joint. The incision having been carried down to the bone, the compact tissue is opened up by gouge and mallet and the diseased cancellous tissue removed by means of the gouge or a spoon. The cavity should be flushed thoroughly with an antiseptic solution and wiped with iodoform gauze. Hemorrhage is controlled by pressure. The incision is then closed by a layer suture and dry dressings are applied.

This operation is most appropriate in cases of localized disease in the internal condyle, as the synovial membrane in that locality leaves a sufficient portion of the bone uncovered to permit ready access without opening the joint. The external condyle is not so readily dealt with, and, in disease of the head of the tibia, the epiphyseal cartilage in children is in danger of being damaged.

Healing usually takes place promptly by primary union. The patient is kept in bed for several weeks and then allowed up on a Thomas knee splint, wearing a light plaster bandage. In many cases this apparatus may be dispensed with in a few months, and a cure established in one-third of the time required by the expectant plan.

Operative Treatment of Local Synovial Disease. Localized synovial disease may be treated upon the same lines as those adopted for localized disease in the osseous tissue. The pedunculated masses which we have described above have been successfully removed by operation. The mass is exposed by a free incision through the capsule and is excised along with a little of the healthy synovial membrane in its immediate vicinity to which it is attached. The exposed portion of the joint cavity is then flushed with sterile normal salt solution. The capsule is sutured with catgut and the superficial wound closed in the usual manner. The after-treatment is similar to that employed after operation for localized caseous deposits, but, if plaster is employed for splinting purposes, it must be divided into an anterior and a posterior portion, which are secured to the limb by bandaging. These should be removed after the first ten days, and sufficient passive movement initiated and maintained to prevent adhesions and a stiff joint.

Operative Treatment of a Diffuse Synovial Disease.—The question of opera-

tion in diffuse synovial disease, and in patients in whom both bone and synovial membrane are involved, must be decided according to the course which the individual case runs. If we find that the disease progresses in spite of efficient expectant treatment, then it is our duty to endeavor to cut the process short by some appropriate operative procedure. Another consideration, to which allusion has already been made, must also affect our decision, namely, that in the adult it may be wellnigh impossible for the individual to afford the length of time necessary to bring about complete cure by expectant treatment, while the disease may frequently be cut short by operation. Operation may also be called for where abscess formation with mixed infection has occurred; partial or complete resection may be necessary to establish efficient drainage.

Arthrectomy. The term is used to indicate an operation by which all the diseased tissues are removed from the joint. This operation is most applicable to children, and in them is altogether and always preferable to complete excision. In the vast majority of cases excision is unjustifiable in children because of the degree of shortening which must necessarily follow the destruction of the epiphyses. On the other hand, arthrectomy is seldom advisable in the adult because an unstable joint is apt to result and it is far better, in most instances, to proceed at once to complete excision and aim at firm bony ankylosis. In the child, although arthrectomy may leave a somewhat unstable joint, yet, by appropriate splinting, after eradication of the disease, the child may be tided over the period of active growth of the limb, and thus, with a minimum amount of shortening, a good result may eventually be obtained. Occasionally, though we must admit rarely, a good, useful, movable joint is obtained after arthrectomy.

Excision.—The results of complete resection of the knee joint for tuberculous disease in the adult have been eminently satisfactory. (See article on "Excisions" in Vol. IV.) The object aimed at is to procure complete eradication of the disease and to secure firm bony ankylosis. Various methods are employed for excising the knee; of these the author has found that introduced by Kocher, of Berne, the most generally useful and satisfactory. This method of incising and opening the knee joint may be employed for excision, for arthrectomy, or for simple arthrotomy. The operation aims at preserving the extensor apparatus of the joint intact. The incision begins over the vastus externus, a hand's breadth above the upper margin of the patella, and passes first vertically downward upon the outer side of the patella, separated from that bone by a finger's breadth; below the patella it is carried with a slight curve inward, and ends on the anterior border of the tibia, having passed beneath the tibial tuberosity. The skin is divided and the strong fascia lata is exposed. This fascia is divided, and will be found specially thick in its lower part. In the upper portion of the wound there will appear the lateral margin of the vastus externus muscle, which must be divided;

below this is the outer surface of the joint capsule, while in the lower part of the wound will be found some fatty tissue and the lateral margin of the ligamentum patellae; below this, again, one cuts directly upon the bone as one passes below the tubercle of the tibia. By means of the closed one proceeds to separate the tibial tubercle with the periosteum and the attached ligamentum patella thrusting it toward the inner side. On cutting through the vastus externus one exposes the external condyle and opens up very freely the recess behind the quadriceps extensor curvis. Lower down, the anterior extremity of the semilunar cartilage is cut away from the tibia without detaching the capsule from it, and it, along with the capsule, is separated from the upper surface of the tibia. One draws inward, with sharp hooks the ligamentum patellae, and, pulling this to one side, one separates the anterior attachment of the internal semilunar cartilage, in front of the crucial ligament, and the capsule, together with the periosteum, is separated, as on the outer side beneath the meniscus, from the cartilaginous internal condyle of the tibia. Now one can dislocate the patella inward. By more and more flexing the joint and loosening the capsule from the tibia below, internally and externally, extreme flexion can be obtained. Next, one must sever the attachment of the crucial ligaments from the spine of the tibia close to the bone as far as the posterior attachments of the menisci. These, with the crucial ligaments, will be separated from the tibia as far as the posterior margin of the bone.

If one must now go on to complete resection, then the crucial ligaments must be separated from the intercondyloid fossa of the femur; as a result of which these ligaments, together with the menisci, the posterior wall of the capsule, and the periosteum, remain in a mass situated posteriorly and still attached to one another. The capsule must then be dissected off the femur. If the lateral ligaments are to be preserved, they must be separated from the epicondyles subperiosteally, and the femur is then sawed with a convex surface, and the tibia with a concave surface, after similarly loosening the capsule with the periosteum from its posterior margin.

When all hemorrhage is checked and the anterior tubercle of the tibia is fixed in position by silver wire, or a nail, the wound is closed by interrupted sutures without drainage. The limb is then secured in a plaster splint until firm bony ankylosis has occurred. It will be found advisable in many cases to remove the patella entirely if complete resection is performed; this bone is frequently diseased and no useful object is served in preserving it when we are aiming at bony ankylosis after resection.

Amputation.—This operation is called for only when the disease is so extensive and progressive that the limb must be removed in order to save the life of the individual.

Tuberculous Disease of the Ankle Joint, Tarsus, and Metatarsus.

Tuberculous disease occurs in the ankle joint with much less frequency

than in the hip or knee. During adolescence and in young adults the disease is much more common than in children. In fact, tuberculous disease of the ankle is a comparatively rare disease in childhood. In the Hospital for Sick Children, Toronto, for example, where the patients are all fourteen years of age and under, there were only 9 cases of ankle-joint disease out of 315 cases of tuberculous arthritis (*i.e.*, about 3 per cent). Tuberculous disease of the tarsus is more common than that of the ankle alone. In the Children's Hospital series the tarsus was affected twice as often as the ankle joint. It would appear that



FIG. 298. Section through the Foot and Ankle of a Child Nine Years of Age, showing the epiphyses of the tibia, of the os calcis, and of the second metatarsal bone. The osseous arch of the foot is apparent. (Original.)

about a similar proportion exists at all ages, as in Cheyne's series the tarsus was affected forty times, while the ankle was involved only twenty-three times.

Anatomical Considerations.—For our purpose here only brief reference need be made to certain of the anatomical features of the ankle and foot. Movement at the ankle joint is restricted almost solely to dorsal and plantar flexion. There is a slight amount of lateral movement possible when the joint is in a position midway between extreme dorsi-flexion and extreme plantar flexion. The lateral movement is permitted while the foot is in the attitude mentioned because while in that position the widest part of the astragalus has passed from between the tibia and fibula, and the ligaments are more relaxed than in the full plantar flexion, so that lateral movement to a limited extent is under

such circumstances possible. When full dorsal flexion is brought about, the anterior and widest part of the superior articular surface of the astragalus passes between the fibula and tibia and even to a slight extent separates the fibula from the tibia sufficiently for its accommodation.

In the mechanism of the foot, the existence of a transverse as well as a longitudinal arch must be remembered, and, in dealing with diseased conditions of the foot, these must be preserved as far as possible; these arches are maintained by strong ligaments, by muscles, and by the plantar fascia. The chief movements between the tarsal bones are those carried out in inversion and eversion of the foot. These movements are very limited in extent between any



FIG. 200. Section through the Foot and Ankle of an Adult, Showing the Construction of the Arch of the Foot at the Instep. (Original)

two of the bones, but the mobility of the foot as a whole is considerable. The strength of the joints between the bones of the foot is chiefly ligamentous; there is little or no osseous strength; that is to say, the articular surfaces do not fit into or grip one another, but for the most part are plane surfaces which are kept in contact by ligaments. These articulations are also greatly strengthened by the insertion of the muscles which are attached to and carry out the various movements of the foot. Figs. 208 and 209 show the construction of the arch of the foot at the instep in the child and in the adult.

The bones of the foot and ankle are made up of cancellous tissue, with but a very thin covering of compact tissue (with Figs. 208 and 209). The articular surface of each bone, too, is seen to be provided with quite a thick layer

articular cartilage. Lastly, attention should be directed to the epiphyseal cartilages. Those at the ankle are shown in section in Fig. 300. It will be observed that the epiphysis of the fibula is placed lower than that of the tibia, and that the epiphyseal disc of cartilage of the fibula is exactly on a level with the superior articular surface of the astragalus. The epiphysis of the os calcis is seen in Fig. 298. It exists upon its posterior extremity.

Etiology and Pathology.—The same etiological factors are at work here as elsewhere, in the production of tuberculous arthritis, and they have already been fully discussed. In the ankle, however, chronic sprain is a more frequent



FIG. 300. Sections through the Ankle Joint of a Child Nine Years of Age, Showing the Epiphyseal Cartilages of the Tibia and Fibula. (Original.)

cause of tuberculous disease than is the case in the other joints. For this reason one should always look upon a sprained ankle as serious, particularly in an individual predisposed to tuberculous disease.

The disease is said to be more frequently primary in the synovial membrane when the ankle joint is affected, and as a rule primary in bone when the tarsus is the seat of disease. Fig. 248 (p. 577) is a good illustration of a sequestrum in the anterior part of the astragalus in an old case of tuberculous disease; the condition of sclerosis of the bone forming the walls of the cavity in which the sequestrum lies is worthy of note. Fig. 301 is a photograph of a frozen section through the foot of a lad seventeen years of age, who ten years previously had had his right ankle joint excised for tuberculous disease. One may observe that complete bony ankylosis has occurred between what remained of the

astragalus and the lower portion of the tibia. While this formative process was going on, the disease progressed in another portion of the tarsus and became extensive and septic, so that amputation had to be performed.

When the ankle joint is the seat of disease, the astragalus is much more often primarily involved than is the tibia or the fibula. Of the tarsal and metatarsal bones the os calcis is most frequently affected, then the first metatarsal, then the astragalus, and lastly the scaphoid and the internal cuneiform. When tuberculous disease of the ankle or tarsus occurs, it is remarkable how the tarsal bones which are not the seat of disease show rarefying osteitis. Plate XXVI.



FIG. 301. Section through the Foot Showing Complete Bony Union between the Tibia and the Astragalus. Excision of the ankle had been done ten years previously for tuberculous disease. (Original)

Fig. 1, is an *x*-ray photograph from a case of tuberculous ankle in which, in a patient twenty years of age, there had been extensive destruction of the ankle joint by tuberculous disease. The skiagraph shows the marked condition of bone atrophy in the tarsus; the compact tissue covering each bone shows up as if it had been pencilled in the picture, while the cancellous tissue shows a diffuse, blurred appearance in marked contrast to the healthy bone, as seen when Fig. 1 of Plate XXVI is compared with Fig. 2 of the same plate, the latter being a skiagraph of the healthy foot.

Another feature of tuberculous disease of the ankle and foot is the frequent occurrence of abscess. Chronic abscess is much more common in ankle-joint disease than in the case of either the knee or the hip. Where mixed infection

occurs and the abscesses open, the whole foot may become riddled with septic sinuses.

The synovial sheaths of tendons about the ankle joint may be affected, and thus a condition of tuberculous teno-synovitis is not an unusual complication.

Symptomatology.—In the early stages of the disease the disability is slight. The patient complains usually of aching and discomfort after walking, and therefore commonly at night. After a time, swelling and pain manifest them-



FIG. 302. Tuberculous Disease of the Ankle Joint in a Child Three Years of Age, Showing the Characteristic Enlargement of the Joint in the Attitude of Equino-Valgus. (Original)

selves. Weight can no longer be borne with comfort, and lameness results. The foot gradually assumes a position of a more or less marked degree of equino-valgus, and the patient bears his weight partly on the heel and partly on the inner border of the foot. The swelling in primary synovial disease may appear anteriorly on either side of the extensor group of tendons, or it may be present posteriorly on either side of the tendo Achillis, more rarely is it perceptible below the malleoli. Sooner or later, however, the swelling becomes uniform and the characteristic fusiform shape of the tuberculous joint makes its appearance. Fig. 302 shows this condition in a child three years of age, in

whom tuberculous disease followed a sprain nine months previously. The normal depressions about the joint become obliterated and the bony prominences are no longer visible.

There is limitation of movement, so that the voluntary degree of dorsal or plantar flexion cannot be carried out, and, while a limited amount of passive movement may be produced without discomfort, yet extreme dorsal or plantar flexion is resisted in a characteristic fashion by muscular contraction. The joint is usually extremely sensitive to any sudden movement, and pain on pressure, particularly over the malleoli, is frequently observed. Slight injuries in the early stage of tuberculous disease of the ankle usually cause an exacerbation of the symptoms, and acute pain may occur which subsides on resting the joint. Increased heat may be observed when the diseased joint is compared with that of the sound side.

Muscular wasting of the calf and thigh is a characteristic feature of the disease, as is wasting of the related muscles in tuberculous arthritis elsewhere.

When abscesses form, they usually come to the surface anteriorly and laterally. If mixed infection is allowed to occur in these abscesses, the trouble at once becomes grave, and septic processes induce much more rapid destruction of the structures in and about the joint. Eventually many sinuses may burrow in the tissues in various directions.

When the disease is primary in the astragalus, an abscess may form and come to the surface outside the ankle joint, but more frequently the disease spreads from the astragalus and invades either the ankle joint or the astragalo-scaphoid joint.

Diagnosis.—It is sometimes difficult to determine the diagnosis as between the stiffness and pain which occasionally exist after a severe sprain, and beginning tuberculous disease. This is especially the case in view of the fact that the latter condition not infrequently succeeds the former. When it is merely a case of adhesions after injury, the condition manifests itself immediately after retentive apparatus has been removed, the foot being comfortable when at rest, but painful when weight is borne upon it. In tuberculous disease, on the other hand, the discomfort is often most marked at night, and the condition tends to become progressively worse. Flat-foot may be excluded in very much the same way; it may also be noted that in this affection the pain and discomfort are localized at the mid-tarsal joint. In flat-foot the swelling will disappear rapidly when rest is provided, and an x-ray photograph will often confirm the diagnosis when tuberculous disease is present.

Septic arthritis runs a much more rapid course than tuberculous disease, and the symptoms are acute. Rheumatism may, as a rule, be diagnosed by the history of the case; monarticular rheumatism is rarely found in the ankle joint. Similarly, arthritis deformans is rarely confined to the ankle, but the possibility of its occurrence must be borne in mind.

Prognosis.—In children tuberculous disease of the ankle is frequently recovered from with complete functional result. In the adult, the prognosis is not nearly so good; abscesses often become the seat of mixed infection, and diffuse septic trouble in the foot not infrequently supervenes. The prognosis in the adult is therefore less favorable than in the child.

Treatment.—The principles involved in efficient treatment here are those already fully discussed in the case of the hip or the knee. When a diagnosis of tuberculous arthritis has been made, it becomes necessary, in the early stage of the disease, to put the joint functionally at rest. This is best accomplished by recumbency and by the application of a well-fitting plaster-of-Paris fixation splint, applied from the toes to a point immediately below the knee. Of course it is not possible to apply the principle of traction to the ankle joint, as was advocated in the knee and hip.

If it is possible to locate definitely a primary focus of disease in the bone, while the joint itself is not yet invaded, then one should remove it by operation without opening the ankle joint. The recognition of such a deposit is rarely possible at the ankle, however, and one should proceed with caution, because it appears that partial and incomplete operations are often responsible for the protraction of the disease, with greater destruction of tissue and greater interference with function than would have occurred had different treatment been adopted.

It being assumed, then, that treatment by fixation and recumbency has been adopted, the progress of the case must be carefully watched, and, when pain and tenderness and all symptoms of acute trouble have disappeared, the patient may be permitted to move about, but on no account should he bear his weight upon the affected limb. The desired result may be secured by the use of crutches, with perhaps some increased thickness of the sole of the boot on the sound side. Another way of effecting our purpose is by using the Thomas knee brace already described in the section relating to the treatment of tuberculous disease of the knee (page 703, Fig. 296).

In connection with this expectant form of treatment, and in fact under all circumstances where fixation is employed, it is essential to see that the position of the limb at the ankle is maintained correctly. Deformity once thoroughly established is often difficult to correct, because of the infiltration of the tissues by inflammatory material and the pain caused on manipulation. The foot must be dorsi-flexed to a position such that the angle of flexion is less than a right angle; the foot may also be slightly supinated to prevent the valgus deformity which tends to occur. If this cannot be accomplished when the patient comes under observation, then it is our first duty to correct the faulty attitude which has been already assumed. This may be accomplished by applying a plaster splint to the limb in its faulty position; and while it is thus splinted, the patient is kept recumbent. After, say, two weeks the plaster is removed,

and then, as a rule, we find that correction of the faulty attitude is possible, the acute symptoms having subsided and muscle spasm no longer existing. If some resistance is still encountered, then in all probability gentle manipulation will effect our purpose, but in certain cases forcible correction under an anæsthetic is necessary. Tuberculous disease involving the ankle joint, when treated by expectant methods, most frequently results in ankylosis more or less complete, and hence the necessity of fixing the joint in the position indicated. If this were not done, the pointing of the toes and the valgus deformity would render progression painful and in some instances wellnigh impossible.

The Bier treatment of passive hyperæmia may well be combined with the conservative methods of splinting which we have just described. The details of this treatment have been described on page 500. The bandage may be applied around the thigh, and the treatment maintained for one hour daily.

The length of time required for effecting a cure will necessarily vary in different cases, but, if the case should run a favorable course under expectant treatment, then from one to two years will elapse before we can safely allow the patient to walk upon the affected limb. A general rule may be laid down that at least six months must elapse after all symptoms of active disease have disappeared before the patient is permitted to move about without a splint.

If the disease continues to progress unfavorably under expectant treatment, then operation is indicated. In the case of the ankle joint, operative treatment is resorted to much earlier than in either the hip or the knee, because we find that, in these operations upon the ankle, an excellent functional result is obtained in the vast majority of instances, and in fact a very much better result than is possible under expectant treatment in cases in which progressive disease has brought about extensive implication of the structures about the joint.

The operation of most service is excision of the astragalus. This allows free access to the joint and permits one to remove all diseased tissue very thoroughly. It has a distinct advantage over excision of the joint because in the latter case bony ankylosis must occur, while after taking out the astragalus alone a movable joint is secured and a much better functional result obtained. The operation is best performed by the method of Kocher, of Berne, which is as follows. A longitudinal incision is made over the antero-external aspect of the ankle, beginning a hand's breadth above the ankle joint on the posterior margin of the tibia, and, after it has been continued vertically to the lower end of the tibia, it is curved forward under the external malleolus and terminated at the tubercle at the base of the fourth metatarsal bone. The incision below lies to the outer side of the extensor muscles and the branches of the musculo-cutaneous nerve. The sheaths of the peroneus longus and brevis are exposed and slit up to the upper angle of the wound. The tendons of these muscles are then divided, but only after two silk ligatures have first been passed through each so that they may be subsequently secured for suture. The three portions of the external lateral liga-

ment are divided close to where they are attached to the external malleolus. The extensor tendons, along with the vessels and nerves, are detached by the periosteal elevator from the anterior aspect of the joint, and the astragalus is bared. The capsule is separated from the anterior aspect of the tibia as far as the internal malleolus, and a similar separation is effected posteriorly. The foot is now forcibly dislocated inward over the internal malleolus, so that the upper articular surface of the astragalus looks downward and the sole of the foot upward. If the external malleolus is the seat of disease, it may be broken in the process, but under such circumstances no harm is done. The astragalus may now be removed after the capsule of the astragalo-scapoid joint has been cut through and subsequently raised from the os calcis by a periosteal elevator, and after the calcaneo-astragaloid ligament has been divided. The joint should now be carefully inspected, and any focus of disease in the tibia or fibula removed; the diseased synovial membrane or ligament must be similarly dealt with. The peronei tendons are then sutured after the foot has been brought back into its proper position, and the wound closed in the ordinary way. The wound is dressed, and the foot, in a correct position, is then secured in a plaster splint. It is advisable to carry the foot well back before securing it in the plaster; this will prevent any tendency of the malleoli to slip off the posterior part of the os calcis, and will also fill in the space that is left at the rear of the scaphoid bone.

Excision of the ankle joint may be performed after the joint has been exposed in the manner advocated by Kocher, as just described. In addition to the arguments already advanced against a formal resection, it should be observed that in children such an operation would necessarily remove the epiphyseal cartilages of the tibia and fibula, thus interfering with the growth of these bones.

Chronic abscesses developing in connection with ankle-joint disease should be treated in the same manner as are similar conditions in the knee and hip. Every effort must be made to prevent mixed infection, and, if the abscess is opened, it should be curetted and stitched up without drainage, so that primary union may occur. Where septic sinuses are discharging, the main principle to be held in view in treatment is the necessity of efficient drainage; for this purpose it may be necessary to remove the astragalus.

Amputation. This is considered only when the disease is very extensive and when destructive processes have advanced in septic cases to such an extent that there is no longer any prospect of saving a useful foot. Syme's amputation is the most desirable form of operation, but in extensive disease it may be impossible to obtain sufficient healthy tissue to carry it out. Under such circumstances it is necessary to amputate higher up the leg.

Disease of the Tarsal Bones Independently of Each Other. Disease of the tarsal bones individually is not uncommon. The os calcis is the one most frequently affected, then comes the astragalus. These two bones afford slightly more than fifty per cent of the reported cases of tuberculous tarsal-bone affec-

tions. Less than fifty per cent of such cases are those in which the remaining bones of the tarsus are affected; of these the cuboid is the next commonly implicated, and then the scaphoid; lastly the cuneiform bones, which are less frequently the seat of disease.

The synovial cavities are so extensive between these bones and the bases of the metatarsals, that disease spreads rapidly and extensively whenever a joint cavity becomes invaded. Fortunately, the disease not infrequently comes to the surface through the thin veneer of compact tissue which covers the bone and does not perforate the comparatively thick layer of articular cartilage. When the joint cavity is invaded, it probably, in the majority of instances, occurs indirectly through the synovial membrane, which may be the primary seat of disease or may be affected by extension from the bone.

Primary disease of the astragalus has already been dealt with in connection with the ankle joint. We have seen that the ankle joint may become invaded from such a focus. Similarly, the subastragaloid joint—the calcaneo-astragaloid articulation—may become invaded from such a focus, or the astragalo-scaphoid joint may in like manner become involved.

In the case of astragaloid disease the symptoms are very similar to those described for the ankle joint. The swelling is, however, at a somewhat lower level, while the ankle joint itself is obviously not affected.

The treatment in astragaloid disease is expectant, along lines already described for the ankle; but should the disease continue to progress, the excision of the astragalus by Kocher's method should be carried out.

Disease in the astragalo-scaphoid joint may be reached by an incision directed over the articulation, should it be thought wise to operate for trouble limited in that locality.

A primary focus in the os calcis is the most common lesion in tuberculosis of the tarsus. When it can be located it is best to remove it by operation. This may be done by an internal or an external incision planned to reach the deposit in the most efficient manner. The bone is readily accessible, either by an external or an internal incision, preferably the latter. The soft parts are separated from the bone by a periosteal elevator, and the focus of disease removed by the gouge in the usual manner. The wound is closed without drainage, and the foot splinted in plaster of Paris in good position.

In extensive disease of this bone complete removal of the os calcis may be called for. This is accomplished through an incision which is carried horizontally around the foot a finger's breadth above the sole. It begins at the base of the fifth metatarsal bone and passes backward around the heel, then along the inner side of the bone for an inch and a half. This is carried through the skin and fascia. A vertical incision in front of and parallel to the tendo Achillis may be added on the outer side. The soft structures are separated from the bone by the periosteal elevator, and the tendo Achillis is divided close

to the bone. The bone must be cleared by careful dissection so that important structures, particularly in the neighborhood of the sustentaculum tali, may not be damaged. Its various ligamentous connections are severed and the bone is removed. The wound is carefully inspected for any diseased tissue, which, if found, must be dissected out. The cavity left is a large one and it may be thought advisable to drain for, say, forty-eight hours, to get rid of blood and serum which might collect and interfere with union. A light plaster-of-Paris splint should be applied. This can be readily taken off for the purpose of removing the drain, and a more substantial plaster splint substituted.

The patient recovers from such an operation with a useful foot. It is about half an inch shorter than its fellow, but this is compensated by a pad of felt or India rubber in the sole of the boot, and the individual is able to walk and to transmit his weight through the foot without discomfort.

The cuboid, scaphoid, or cuneiform bones may be removed individually for localized foci of disease. Such cases, if the operation is successful in eradicating the disease, recover with a good functional result. The cavity left after removal of the bone is soon filled with tough fibrous tissue, or possibly by some osseous formation, and the stability and usefulness of the foot are thus maintained.

Diffuse Tuberculous Disease of the Tarsus. Where the tarsal bones and the synovial membrane are extensively involved, amputation is necessary in most instances. Where mixed infection has occurred and a septic condition exists, then here, as elsewhere, efficient drainage must be secured; and if removal of the bone is necessary to effect this purpose, then the bone must surely be sacrificed. But where the course of the disease has been very chronic, where there has been no septic trouble, and where the patient is in other respects a healthy subject, the operation of partial or complete tarsectomy may be undertaken.

Mikulicz's operation of complete tarsectomy consists in dividing the bones of the foot through the bases of the metatarsal bones, or, if the position of the disease warrants it, the cut across the bones of the foot may be through the distal part of the tarsus. The bones of the leg are divided immediately above the ankle joint. The incisions are so devised that along with the os calcis the skin and soft structures about the heel are removed. The anterior part of the foot is then brought into a straight line with the leg, and the sawed surfaces of the leg bones secured by silver wire to the sawed surfaces of the metatarsals or the remains of the tarsus, as the case may be. The wound is closed and the limb efficiently splinted. The splinting should be arranged so that the toes are pressed forward to form a right angle with the metatarsus.

The results of Mikulicz's operation have not been eminently satisfactory, and in most instances a more useful member may be secured by amputation and the use of an artificial foot.

When the disease is in front of the mid-tarsal joint, partial tarsectomy may be performed. This may be accomplished by two lateral incisions, the outer one being rather dorso-lateral in position. These incisions are carried down to the tarsus. The soft structures are separated from the bone in the usual way, and the tarsus is sawed through across the neck of the astragalus, the os calcis being divided in the same plane. Another transverse saw-cut is made across the heads of the metatarsal bones, and the anterior portion of the tarsus, along with the bases of the metatarsals, is removed. All diseased tissue is dissected away and the wound closed with or without drainage, depending on the amount of subsequent oozing which is anticipated in the individual case. Wiring is not necessary, but the foot is brought into good position and secured in plaster. As healing takes place, the various structures contract and shorten, and a very good functional result is obtained, with, of course, a greatly shortened foot.

While little can be said in favor of complete tarsectomy, there can be no doubt that partial tarsectomy, in suitable cases, yields a good result, and, when the disease can be eradicated by this means, it is preferable to amputation.

In the presence of numerous septic sinuses, with extensive infiltration of the soft tissues, Syme's amputation at the ankle joint is the better operation.

Tuberculous Disease of the Metatarsals. In fifty per cent of such cases the disease is situated in the first metatarsal bone, and usually at the base. When it can be located there it should be removed by operation. If the focus of the disease is in the base of the bone, the incision should be made along the axis of the affected metatarsal just external to the extensor tendon. Beginning over the internal cuneiform bone above, it should extend down to about the centre of the bone. The soft parts are separated and the bone is severed by cutting-pliers. The ligamentous connections are then divided and the diseased bone removed. The wound is dressed and the foot splinted.

The results after such an operation are excellent. Dense fibrous tissue replaces the bone removed, and a perfect functional result is obtained.

Metatarsal bones other than the first may be similarly treated when localized foci of disease are recognized.

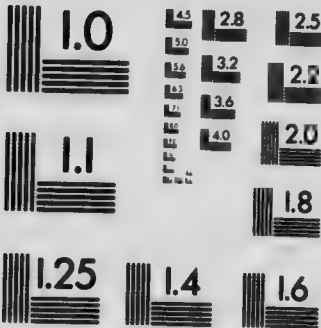
Tuberculous Disease of the Phalanges of the Foot. The condition, or "spina ventosa" is occasionally met with in the foot, especially in children. This affects, as a rule, the phalanges, but now and then one of the metatarsal bones is similarly involved. The metatarso-phalangeal or the interphalangeal joints may also become involved.

These cases are best treated by operation. In children the bones may be cut down upon and thoroughly curetted, or resection of diseased bone may be undertaken, and thus the disease is not infrequently eradicated. Should this procedure not prove successful, then amputation of the digit or the diseased portion of the digit should be performed, and, in the adult, amputation



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is advocated as the better procedure for the primary operation. An exception may be made of the metatarso-phalangeal joint of the great toe, where in all cases excision of the joint should be attempted before amputation is resorted to, because of the importance of preserving the great toe as a basis of support in the foot.

Tuberculosis of the Long Bones of the Extremities.—Reference has already been made to the fact that tuberculous disease may affect the long bones at points distant from the joint (page 579). We have elsewhere described the disease as it appears in the long bones of the foot and hand. The pathology of the condition has been discussed. A chronic periostitis may be the first manifestation of the disease, and extensive destruction of bone may result, or the disease may begin in the medulla of the bone, constituting a tuberculous osteomyelitis. Chronic abscess in bone most commonly develops near the articular extremity; in such cases the x-ray may prove a valuable aid to diagnosis. Fig. 254 illustrates a chronic abscess in the lower end of the right radius, as shown by this means. The patient was fifteen years of age and complained of pain, swelling, and stiffness of the right wrist; the symptoms of trouble had existed for three months. An operation was performed and the abscess opened after chiselling through the compact tissue.

The disease is very insidious in its onset and runs a chronic course. Pain and disability constitute the early symptoms. The pain is most troublesome at night. Local tenderness is detected on manipulation, and swelling at the seat of trouble gradually develops. Abscess may form, and, where mixed infection occurs, the usual sequence of events will be noted, involving long-continued suppuration and the persistence of septic sinuses.

Treatment.—The general principles of treatment laid down for tuberculous arthritis are applicable in the cases now under consideration. Expectant treatment is to be advocated in the early stage of the disease; the part is to be kept at rest by suitable splinting.

If progress toward recovery is not made, then the bone must be laid bare and the tuberculous disease removed by curetting with a sharp spoon. If there has been no mixed infection the wound should be closed without drainage. If the wound becomes septic, then free drainage must be secured and the wound packed with sterile gauze and allowed to granulate.

The treatment of chronic abscess and the treatment of septic cases must be carried out along the lines already advocated for such conditions in connection with tuberculous arthritis.



